FINAL REPORT

19980158

WEED CONTROL INITIATIVE: TECHNOLOGY ADOPTION AND DEMONSTRATION

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Noxious Weed Management Program
Final Report

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Weed Control Initiatives: technology adoption and demonstration

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Weed Control Initiatives: technology adoption and demonstration

(a) Summary

The objectives are to deliver a provincial scentless chamomile awareness and control program, featuring biological control, and to monitor the biological control of leafy spurge.

The integrated weed control approach focused on awareness, education and control. Local governments were encouraged to organize right-of-way weed control and appoint Weed Inspectors. Emphasis was on stopping weed spread.

Presentations (64) and print articles (34) were delivered. Information booths (3) were manned at the Spring SARM Conventions and presentation (2) were delivered at the Fall SARM Conventions.

A proactive plan featured biological control. Scentless chamomile seed weevils were mass reared over winter.

(b) Technical Report

Background

Saskatchewan Agriculture and Food (SAF) have administered a distribution program for perennial weed biocontrol agents since 1989. From 1989 to 1995 a formal program was conducted that focused on leafy spurge biocontrol. Funding was received from ADF and the Canada-Saskatchewan Agriculture Green Plan Agreement over this period of time. Scaled down projects were conducted in 1996 and 1997 with some assistance from SAF and Saskatchewan Environment and Resource Management (SERM).

The program was successful over this period of time with 263 field days held, over 130 mother colonies (leafy spurge) established in participating municipalities and over 400 collections of biocontrol agents were made by municipalities/landowners/Reserves for distribution on their own land. In addition, there were over 100 releases of a weevil on scentless chamomile and controlled releases on bladder champion, toadflax and nodding thistle. Although SAF continues to invest in the screening of biocontrol agents, the distribution program has slowly declined because of the lack of field monitoring and central coordination. The result is also a lack of information for municipalities, Extension staff and landowners.

SAF has invested, through Agriculture and Agri-Food Canada, $523,000 into the collection and screening of biocontrol agents in Europe since 1987. However, there is no infrastructure for the release and monitoring of potentially successful biocontrol agents coming from this program.

In regard to scentless chamomile, it is slowly spreading across the province. Because of its growth habit and resistance to many common broadleaf herbicides (e.g. 2,4-D, MCPA, dicamba) it is becoming an increasing problem, especially in specialty and forage crops. The most effective herbicides have soil residual properties and therefore can drastically affect crop rotation options. Over the past number of "wet" years, chamomile has spread dramatically, it infests annual crops, forage crops, roadsides, wildlife habitat and specialty crops such as herbs and spices. If unchecked it will continue to limit diversification opportunities for many producers, lessen the value of forage crops and cause significant economic loss.

A provincial Scentless Chamomile Action Committee, with membership representing producers and other stakeholders, will be formed to direct the scentless chamomile awareness and control program.

Objectives

To monitor existing colonies of biocontrol agents released for the control of persistent perennial weeds, including scentless chamomile and to release additional biocontrol agents on persistent perennial weeds as they become available.

To develop and implement a provincial scentless chamomile awareness and control program.

To conduct an extensive review of and consultation related to the Noxious Weeds Act with the aim of developing a new Act that reflects the needs of the changing agri-food industry and municipal governments.

List of Project Activities

Biological Control

1. Contact all stakeholders involved with the release of biocontrol agents for leafy spurge and other weeds to collect general information on the weed and develop an updated inventory of sites.

2. Contact Agriculture and Agri-Food Canada (AAFC) to updated general information and future plans for biocontrol of leafy spurge, scentless chamomile and other weeds.

3. Provide consultative services to rural municipalities to implement control programs.

4. Develop a schedule of biocontrol sites for leafy spurge and other weeds for inspections and monitor.

Scentless chamomile

5. Contact all stakeholders involved with the release of scentless chamomile biocontrol agents to collect general information on the weed and develop an updated inventory of sites.

6. Contact Alberta Research Council (ARC) to updated general information and future plans for biocontrol of scentless chamomile.

7. Review, update and develop appropriate extension material for Saskatchewan.

8. Develop a plan of action in consultation with partners, including public awareness and media campaigns.

9. Develop a schedule of workshops, farmer meetings and field days for presentation and information distribution.

10. Inform media of field day presentation opportunities.

11. Conduct site inspections and hold field days as required for redistribution of established biocontrol agents.

12. Establish mother colonies of new biocontrol agents as required.

Project Activities and Achievements

Introduction

A list of articles by the author and generated by the project is presented in Appendix A on compact disk. A list of presentations is presented in Appendix B on compact disk. Presentations made during the project and photographs are on compact disk.

Biological Control

Project Activity 1.

Contact all stakeholders involved with the release of biocontrol agents for leafy spurge and other weeds to collect general information on the weed and develop an updated inventory of sites.

Achievements

An inventory of the sites where biological control agents were released for the suppression of leafy spurge and scentless chamomile was prepared (Appendix C and D). Details for scentless chamomile is presented in Project Activities 5 to 12 of this report.

Leafy Spurge Classical biological control agents, sheep, goats and herbicides are often used to control leafy spurge. This project focused on the establishment success of three classical biological control agents.

Eleven of the 17 insect species that were released for the control of leafy spurge have established (Harris 2000e). According to Dr. Harris, six or seven species are likely to be needed for the complete control of leafy spurge.

Black dot (*Aphthona nigriscutis*), brown dot (*A. cyparissiae*) and black (*A. lacertosa*) leafy spurge flea beetles were released in Saskatchewan for the control of leafy spurge. On the Canadian prairies, the black dot beetle was released in 1982 and 1986, the brown dot beetle was released 1982-6 and the black beetle was released 1990-3 and 1996-8.

Since the first release of the *Aphthona* beetle was made in Saskatchewan in 1982, there have been over 500 releases made all over the province (Bolton 1989, Bolton et al. 1994, LaLonde and Torkelson 1995, York Consulting Inc. 1991, York Consulting Inc. 1992). An on-going inventory for successful establishment of the three species of leafy spurge beetles was maintained between 1989 and 1995. During that time, release sites were visited and presence of leafy spurge beetles was assessed.

In 1995, an inventory of leafy spurge beetle release sites was summarized in a table, which was titled, Leafy Spurge Biocontrol Site Summary. An electronic version of this table was maintained on a diskette. In addition to the information on beetle establishment, the table listed the name and the telephone number of a contact person who was responsible for a release site.

In the spring of 1999, an attempt was made to telephone and interview all of the contact persons

listed on the inventory list. Each contact person was asked if leafy spurge beetles were present on the site and if there was any reduction in the population of leafy spurge. This information was added to the updated inventory list. Sites that were destroyed or sites where the beetles failed to establish were removed from the list. The new list, which contained the location of release sites that were known to harbour beetles, was named; List of Sites for Collecting Spurge Flea Beetles.

Valuable information on the biology of the leafy spurge and a good description of the biological control agents was available in a 1997 publication, which was titled; 'Integrated Biocontrol Strategies for Noxious Weeds; Field Reference Manual'. The text from the manual was ocular read. This information was updated with the most current information that was available on the website of the Lethbridge Research Centre (Harris 2000a-e). The updated text on the weed and the biological control agents was combined with the List of Sites for Collecting Spurge Flea Beetles in a new report called; The 1999 U-Pick Leafy Spurge Flea Beetle Information Guide. Also, included in the new report were update forms, which are completed when the leafy spurge beetles are released or monitored.

The 1999 U-Pick Leafy Spurge Flea Beetle Information Guide was a 43 page electronic article. It was e-mailed to all Extension Agrologists in the province. During 1999, Extension Agrologists had the most up-to-date information on beetle establishment and the locations of the release sites within the province. The 1999 edition was updated for 2000, 2001 and 2002. The latest information on biology of the biological control agent was added each year. Also, information on monitoring in 1999, 2000 and 2001 was added yearly. In 1999, 2000 and 2001, 17, 36 and 40 sites were visited and monitored, respectively. In 1999, 2000 and 2001 there were 0, 28 and 28 new releases listed. This information was obtained from release forms that were completed by producers and agencies within the province. Each spring, Extension Agrologists were e-mailed a new version of the electronic article: U-Pick Leafy Spurge Flea Beetle Information Guide.

The U-Pick Leafy Spurge Flea Beetle Information Guides are used by Extension Agrologists to advise clients on the locations of release sites for the collection of leafy spurge beetles.

Sites monitored before 1999 were compared to sites that were monitored between 1999 and 2000 (Table 1). On sites monitored before 1999, there were more sites with 10 or more leafy spurge flea beetles per sweep than on the sites that were monitored between 1999 and 2001. The reason for the decline is unknown. Ten beetles per sweep is a reasonable number of beetles at a site for it to be worthwhile visiting for collection. In the United States, they suggest a minimum of 1 - 2 beetles per sweep or 500 per hour (Merritt et al. 2000). There are few good sites in Saskatchewan for leafy spurge beetle collection.

Table 1. Presence of leafy spurge flea beetles on release sites in Saskatchewan.

	Sites monitored before 1999	Sites monitored 1999 - 2001
No beetles present	2	7
<1 - 10 beetles per sweep	23	70
>10 beetles per sweep	16	7
Sites not sampled	59	

Most of the sites that were classed as not monitored in Table 1 were releases that were made during 2000 and 2001 (Table 1 and 2). The optimum time to monitor these sites for collection and re-distribution is 2 to 3 years after release.

Table 2. Leafy spurge flea beetles on release sties that were not sampled.	
Year beetles released	Number of release sites
Before 1999	3
1999	0
2000	28
2001	28
Total	59

During January 2001, Dr. Bob Richard, a member of TeamSpurge in the United States telephoned Bill Houston, Prairie Farm Rehabilitation Administration, and offered Saskatchewan 100,000 black leafy spurge beetles (*A. lacertosa*). Bill Houston obtained an import permit for 2001. TeamSpurge members collected and gave Saskatchewan 190,000 black beetles, which were release at four locations, along the Wood River (50,000), Last Mountain House Park (44,000), Davidson (48,000) and Corman Park (48,000). The beetles were released using the latest release information from TeamSpurge. At a release point, 6,000 beetles were released and the release points were 25 paces apart. The objective was to release large numbers of beetles in favourable locations to have nursery sites for collection in 3 to 5 years.

Yellow Toadflax *Mecinus janthinus* is a stem-mining weevil that has established on Dalmatian toadflax in British Columbia. Establishment of the biological control agent on yellow toadflax in Alberta has been variable. The climate of western Canada is generally colder and drier than the native habitat of the stem-mining weevil in Europe. Therefore, an insect that lives in plant stems may not be able to survive Canadian winters when there is little snow cover. Dr. McClay, at the Alberta Research Council is presently testing the hypothesis that snow cover affects the establishment of *M. janthinus*. Releases in Saskatchewan should be delayed until the conditions for successful establishment are known.

Field Bindweed *Aceria malherbae* is a gall mite that distorts and stunts the growth of field bindweed. This agent has established in southern Alberta and Montana on humid sites. *A. malherbae* could be released in Saskatchewan but only on sites were field bindweed grows on land that is irrigated yearly. No attempt was made to release *A. malherbae* in Saskatchewan.

False cleavers *Cecidophyes rouhollahi* is a gall mite that stunts and twists the growth of false cleavers. Petition for field release is being evaluated. Once the petition is approved and research has demonstrated that *C. rouhollahi* can establish on the Canadian prairies then arrangements should be made to release the biological control agent in Saskatchewan.

Common tansy This weed is a potential target for biological control on the Canadian prairies. Field surveys in Europe have identified several insects as candidates for biological control.

Interest for a biological control project for common tansy comes from British Columbia, Montana, Idaho and South Dakota. In Saskatchewan, the weed should be assessed for the necessity of initiating classical biological control in Europe.

Project Activity 2.
Contact Agriculture and Agri-Food Canada (AAFC) to updated general information and future plans for biological control of leafy spurge, scentless chamomile and other weeds.

Achievements
Dr. Rob Bourchier is the Research Scientist at the Lethbridge Research Centre who is responsible for research activities on the biological control of leafy spurge. Twice a year, Dr. Bourchier was telephoned for an update on newest information on the biological control of leafy spurge.

In 1999, Dr. Bourchier pointed out that there is a need for a strategy for the placement of released beetles. His goal is to establish collection sites within each municipal district in southern Alberta. In 1997, the black spurge beetle (*A. lacertosa*) was released on 50 sites in southern Alberta. On the Blood Indian Reserve, there was 100% establishment. This success is partly based on the release of 2000 - 4000 beetles per release point. Dr. Bourchier releases 2000 beetles on good sites and 4000 beetles on poor sites around Lethbridge, AB. The recommendation from the 5-year TeamSpurge project is 6000 beetles per release point (personal communication, Chad Prosser). In Saskatchewan, the release number reported in the The 2001 U-Pick Leafy Spurge Flea Beetle Information Guide is 1000. This is the similar to the release number reported in leaflets from the Lethbridge Research Centre (Harris 2000a-d). The recommended release number in a popular publication in the United States is 1000^{+} (Merritt el al. 2000). The recommended number of beetles to release per release point is variable. The reason for the often-recommended number of 1000 beetles is the lack of sites for collecting a large number of beetles quickly. Dr. Neil Spencer, USDA, suggests that the performance of the leafy spurge beetles decreases from south to north in North America (personal communication). Because of the wide variation in release numbers, beetle releases based on research from southern Alberta, Montana and North Dakota should be monitored carefully for establishment success rates. In Saskatchewan, the success of large release can be evaluated by monitoring the establishment of the 2001 releases of 6000 per release site at Davidson and Saskatoon.

In the spring of 2000, Dr. Bourchier explained the situation surrounding the introduction of two new biological control agents into the United States. The agents are a stem-boring beetle (*Thamnurgus euphorbiae*) and a gall midge (*Spurgia capitigena*). The gall midge lays eggs near the growing tips of the plant causing the formation of a gall. The gall reduces the weed's ability to flower and thus produce seed. The stem-boring beetle tunnels into leafy spurge stems to lay eggs. Larvae hatch from eggs, feed on stems and weaken the plant, which reduces seed production. These new releases were reported in the Canadian press. Dr. Bourchier thinks that the United States has funded the collection of the insect from a new area in Europe for re-introduction. The timeline for the expected release of the stem-boring beetle into the United States is 2001. This expected release has been totally funded by the United States. The stem-boring beetle is from a warmer climate (Italy) than is found in western Canada. A past release

from Italy, the copper flea beetle (*Aphthona flava*), requires more heat units than are available in western Canada. It is unknown but the stem-boring beetle may require more heat units than are available in Saskatchewan. The best strategy with the stem-boring beetle is to study the success of establishment in the United States.

Low Beetle Number The number of leafy spurge beetles that were recorded during monitoring in 2001 was less than the number recorded in 2000. In August of 2001, Dr. Bourchier was telephoned for a scientific explanation for the low beetle number. He had not looked at the Alberta data that was collected during the year but said the beetle numbers in United States were lower in 2001 than in 2000. According to Dr. Bourchier, the phenology of leafy spurge relative to the beetles was different during 2001 than in 2000. In 2001, leafy spurge started growth earlier in the season and because of the cool-dry conditions, the emergence of spurge beetle was later. In Dr. Bourchier opinion, these phenologically differences caused fewer beetles to emerge. Also, Dr. Bourchier thinks that 2000 was the more normal year. This suggests an extra effort should be made to collect and re-distribute leafy spurge beetles during years when the beetle populations are high.

Education at Beetle Release Sites When most beetle release sites were monitored, the local contact person was present. Sometimes the contact person would invite nearby neighbours to be present when a release site was visited. Interest in biological control and the success of the beetles was high. Often, these site visits lasted over an hour because of the questions that were asked about how the beetles will control leafy spurge. Most often, the beetles had established but their performance had not met the client's expectation. Once the visitors saw the thinned out spurge and understood that control is slow, they were appreciative but were not satisfied with control. The issue was a lack of education. It became quickly apparent that this approach was successful but reached only few clients.

Dr. Bourchier experience was similar. He found that there is high value in the slow but effective process of one-on-one with those who are interested in the use of beetles to control leafy spurge. In Alberta, he said that about four of the 95 releases that were made during 1997 are doing well. Untrained people chose the release sites. When a trained research technician selected release sites on the Blood Indian Reserve in southern Alberta, almost all of the sites flourished with beetles. This suggests that site selection is very important for beetle establishment. In Saskatchewan, site selection should not be left to untrained people. Presentations in Saskatchewan, should included information on appropriate site selection.

Canadian Pacific Railway Beetle Releases On behalf of the Canadian Pacific Railway, Dr. Bourchier release leafy spurge black beetles at four sites on railway property in the rural municipality of Longlaketon. Dr. Bourchier recommends the black beetle as the best beetle to collect and release in western Canada. At each site, 4000 black beetles were released.

Research on Biological Control for Scentless Chamomile Dr. Rose DeClerck-Floate is the Research Scientist at the Lethbridge Research Centre who is responsible for research activities on the biological control of scentless chamomile. Her research on agents to control scentless chamomile is dwindling but she agreed to analysis scentless chamomile seed head samples for seed weevils. Most of the future research on the biological control for scentless chamomile will

be done by Dr. Alec McClay who is employed by the Alberta Research Council (ARC) at Vegreville, Alberta.

In 1999, scentless chamomile seed head samples from 18 of the best sites were collected and sent to Dr. DeClerck-Floate. In 2000 and 2001, seed head samples were collected from 18 and 16 sites, respectively. During 1999 and 2000, two of the sites were sampled by Mr. D. Patience. Dr. DeClerck-Floate dissected and analyzed the seed head samples for the presence of the scentless chamomile seed weevil.

In 1999, over 40% of the scentless chamomile seed heads contained at least one seed weevil (Figure 1). In 2000, 70% of the seed heads contain at least one seed weevil but in 2001, the number of seed heads that contained at least one seed weevil decreased to less than 40%.

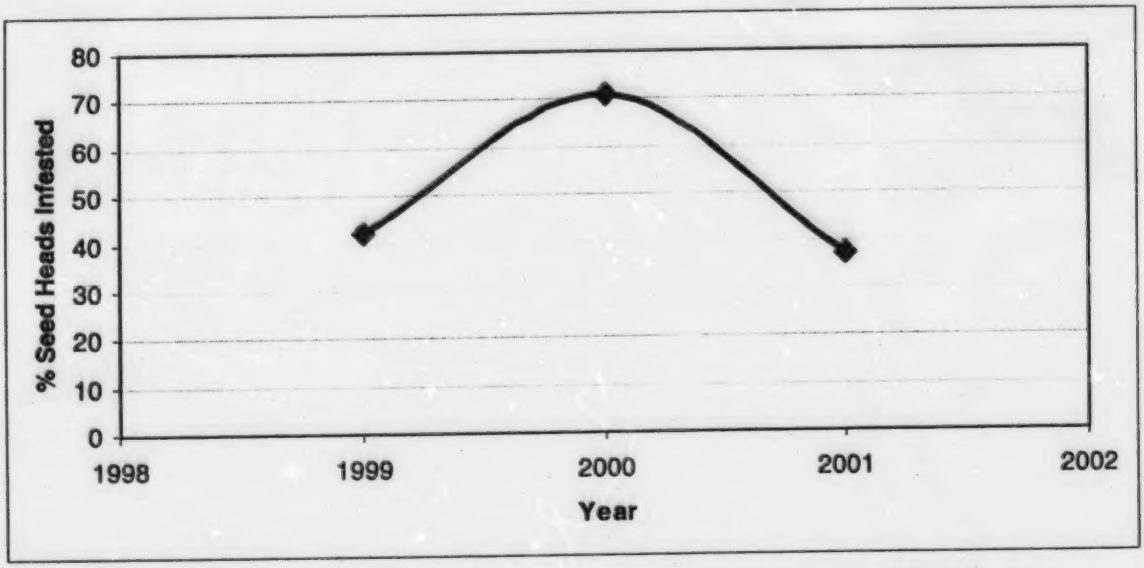


Figure 1. The mean number of scentless chamomile seed heads with a minimum of one weevil per seed head from 1999 to 2001.

The mean number of seed weevils per infested seed head was similar from 1999 to 2000 but decreased during 2001 (Figure 2).

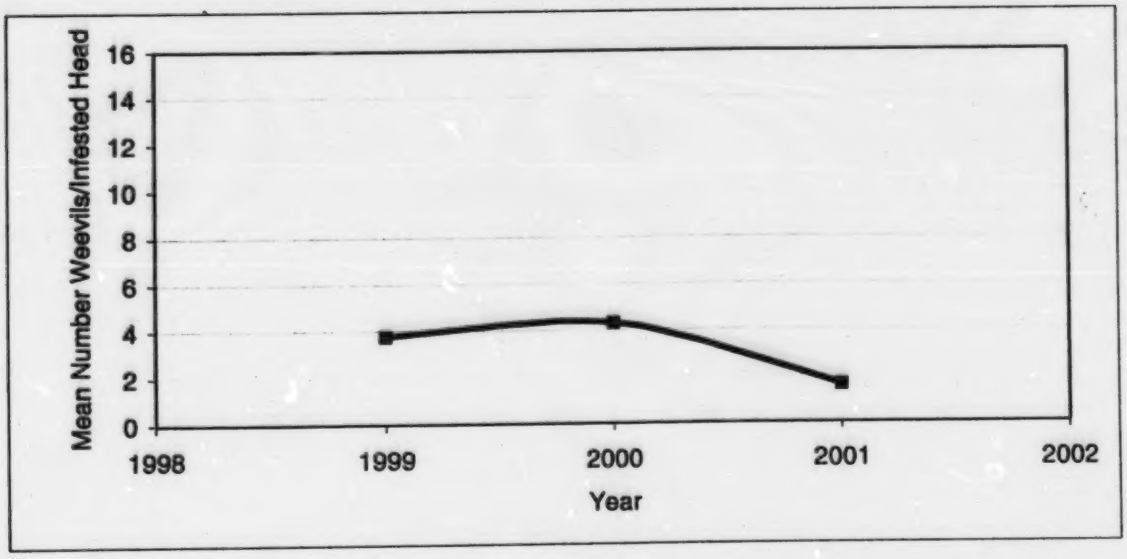


Figure 2. The mean number of scentless chamomile seed weevils per seed head from 1999 to 2001.

The reason for the decrease in the number of scentless chamomile seed heads infested with at minimum of one seed weevil per seed head and the number of seed weevils per infested seed head is unknown. Two hypotheses can be formed to explain the decrease. First, precipitation during 2001 was below normal in Saskatchewan. Because scentless chamomile prefers to grow in moist to wet soil, the moisture content of the weed may have been lower than normal and the weed may have been a poor food source. Second, the weevils may have attained their maximum population increase and the change from 2000 to 2001 may have been natural variation in the environment.

During 2000, a single scentless chamomile plants was collected from a 1996 release site and sent to Dr. DeClerck-Floate (Table 3). She dissected and analyzed the flowers-seed heads on the plant sample for the presence of the scentless chamomile seed weevil. The flower-seed heads were numbered 1 to 25 with the first appearing flower assigned number 1. Only 9% of the seed were attacked in flower-seed head numbered 20 to 25 compared to 49% of the seed attacked in the flower-seed heads numbered 1 to 19. It appears that late flowers can escape an attack by the seed weevil.

Table 3. Damage caused by seed weevils on a scentless chamomile.	
Number of larvae attacking the plants	154
Number of flowers on the plant	25
Percent seed destroyed on the plant	40
Percent seed destroyed flowers numbered 1 to 19	49%
Percent seed destroyed flowers numbered 20 to 25	9%

Team Approach for Biological Control The long-term success of biological control in Saskatchewan depends on the collection of new insects in Europe, their screening in Europe or Canada, and multiple field releases in the province. During 2000, a meeting to plan biological control was held at the Saskatoon Research Centre (AAFC) in Saskatoon. Information was exchanged on the collection of biological control agents in Europe (Dr. H. Hinz, CAB International), screening in Canada (Dr. A. McClay, Alberta Research Council, Vegreville) and field releases in Saskatchewan (Dr. G. Bowes, Noxious Weed Program and Mr. C. Brenzil, Provincial Weeds Specialist). To provide a better understanding of the ecology of Saskatchewan release sites, 36 photographs that were taken in 1999 and 2000 were scanned, documented and e-mailed to Dr. Hinz.

The fate of the insects collected in Europe and tested for potential biological control agents in Saskatchewan is presented in Table 4 (Hinz and Cripps 2001). Of the eight potential agents found in Europe, only three were suitable for release into Saskatchewan. Four of the potential agents were rejected because they attacked either herbal chamomile or *Chrysanthemum* spp. At present, there are no insects being tested for the biological control of scentless chamomile in Europe or in quarantine in North America.

Table 4. Fate of 8 biological control agents collected in Europe.	
Seed weevil (*Omphalapion hookeri*)	Approved for release 1993
Stem-mining weevil (*Microplontus edentulus*)	Approved for release 1997
Stem-mining weevil (*Microplontus rugulosus*)	Research stopped: weevil attacked herbal chamomile
Root-feeding weevil (Diplapion confluens)	Research stopped: attacked herbal chamomile and *Chrysanthemum* spp.
Root-feeding weevil (Coryssomerus capucinus)	Research stopped: attacked herbal chamomile and *Chrysanthemum* spp.
Gall midge (*Rhopalomyia tripleurospermi*)	Approved for release 1999
Agromyzid fly (*Napomyza* sp. near *lateralis*)	Research stopped: weevil attacked herbal chamomile
Agromyzid fly (*Botanophila* sp. near *spinosa*)	Research discontinued: not able to rear in captivity

Project Activity 3. Provide consultative services to rural municipalities to implement control programs.

Achievements

Integrated Weed Control Programs The model for the integrated weed control program for leafy spurge is presented in Figure 3. Presentations made in Saskatchewan were based on this model.

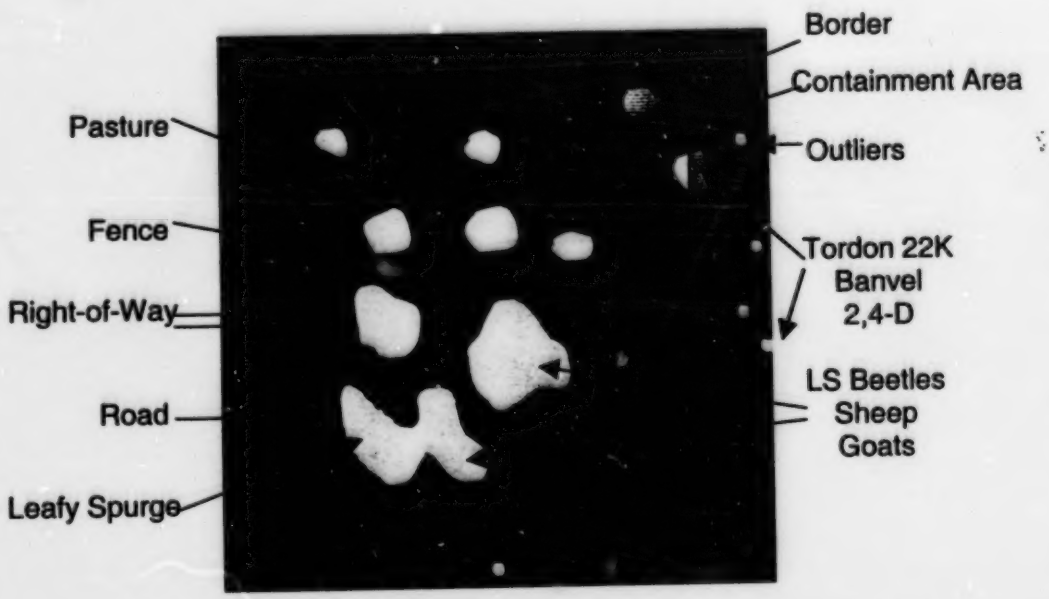


Figure 3. For large areas infested with leafy spurge use Contain and Control: treat the border with a herbicide (repeat as required) and use biological control within the containment area.

Recommendations for the control of leafy spurge were base on integrated weed control. Contain and control was emphasised. Scout a leafy spurge infested area to decide on the best place for a border area. The purpose of a border is to stop the spread of leafy spurge to areas outside of the border. Outside the border area, owners and occupiers of land can expect to find small patches of leafy spurge. These are called outliers. Treat these patches with herbicides, as often as necessary, to control the weed. In this case, control always means preventing seed set. Inside the border area use biological control agents, goats and/or sheep to suppress the weed population. In this case, suppression means reducing the population of leafy spurge to a minor plant species in the vegetation.

During 1999, integrated weed control programs were delivered to rural municipalities for leafy spurge (RMs #45 and #344) and scentless chamomile (RMs #305 and #345). Special programs were designed for the rural municipalities of Mankota #45 and Corman Park #344. At Mankota, the rural municipality had applied Tordon 22K to control leafy spurge that was growing on rough land. Black leafy spurge beetles (>15,000) were collected and released on leafy spurge plants that missed the herbicide treatment. The theory of this project was to use Tordon 22K to reduce the leafy spurge population to a low level and hope that the beetle population could increase rapidly and suppress the weed when it tries to re-establish. Within Corman Park #344, there was interest in the control of leafy spurge but not with herbicides. Black leafy spurge beetles

(>15,000) were collected and released during 1999 and 2000. During the 1990's, several released of the brown dot beetles were made within the rural municipally. In 2001, Corman Park used sheep on the site where beetles were released. A TeamSpurge project showed the combination of beetles and sheep has successfully suppressed leafy spurge (Samuel 2002). In the test area, the beetles had established before sheep grazing but the beetles were not suppressing leafy spurge to the client's satisfaction. The results of this multi-species biological control approach will not be known for 3 to 5 years.

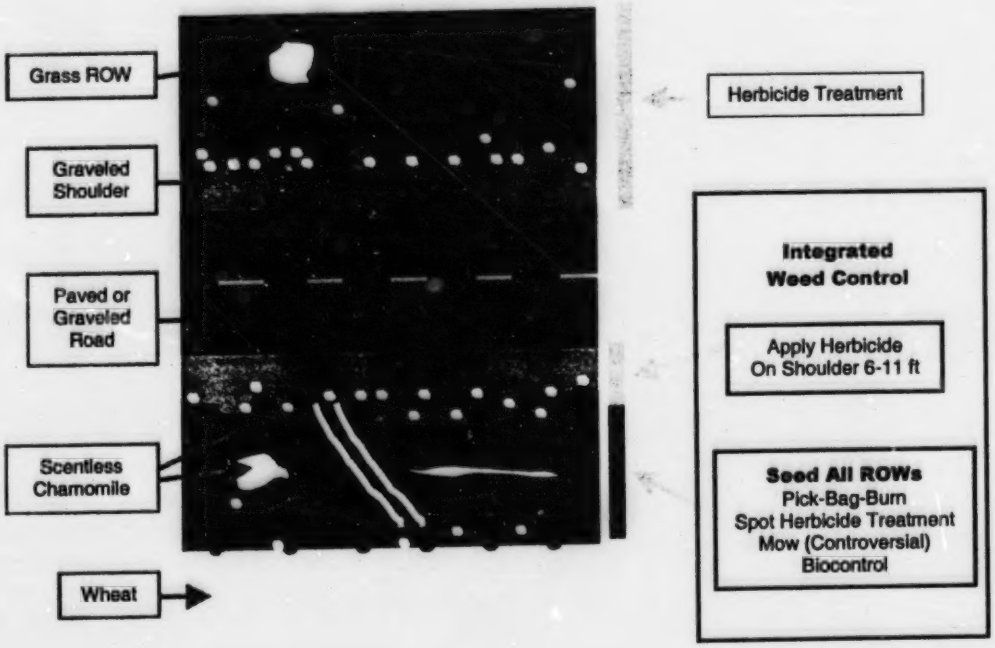


Figure 4. The integrated weed control program for scentless chamomile focused on the need to prevent weed spread along agricultural and industrial rights-of-ways.

For scentless chamomile, a weed control program needs to stop weed spread. The integrated weed control program used herbicides to control the weed on road shoulders, grass competition in combination with pick-bag-burn for the remainder of the right-of-way and the appropriate agricultural herbicides for weed control in field and forage crops. Seed weevils, stem weevils and gall midges should be released in areas, including rights-of-ways, that are safe for the biological control agents and where scentless chamomile seed cannot be easily moved by natural and human activities.

In the fall of 1999, a one-page handout of the integrated control model for scentless chamomile

was prepared. This model is included in information packages that were sent to those who request information. To help to address awareness for those who were having trouble identifying scentless chamomile, eight photos were formatted into MSWord files and were sent by e-mail, on request. While the photos were needed, their print quality was poor. The photographs were discontinued when the scentless chamomile posters became available.

Interest in Scentless Chamomile Control Over the winter of 1999 - 2000, interest in the control of scentless chamomile continued to increase. Awareness and education of scentless chamomile was the theme of presentations at extension meetings that were held throughout rural Saskatchewan. The meetings were organized by Extension Agrologists. Reeves, Councillors and Administrators of rural and urban municipalities attended the meetings. By speaking at different organized events (for example, a pulse meeting and a grassland conference), large sectors of Saskatchewan were made aware of the scentless chamomile before the weed became a problem. Some Extension Agrologists organized special meetings on the integrated control of scentless chamomile. A complete list of presentations is presented in Appendix B.

Strategy Meeting On November 25, 1999, a meeting was held with the Northeast Extension Agrologists to develop a strategy on how to deliver a control program for scentless chamomile. The strategy agreed on was the continuous delivery of the integrated weed control approach for the weed.

Common tansy At the Northeast Extension Strategy Meeting, the Extension Agrologists indicated that common tansy was a problem in a number of rural municipalities. Common tansy was observed growing along fence lines and in road rights-of-ways but did not appear to be invading agricultural land. In the fall of 2001, Ducks Unlimited indicated that the weed is starting to move into their wildlife land. Ducks Unlimited agreed to continually monitor and document the invasion of common tansy. Several months later, in a conversation with Dr. James Jacobs of Montana State University, he said that common tansy is a weed of fence lines and road right-of-ways. This is similar to habitats that the weed occupies in Saskatchewan. It is important to beware of Ducks Unlimited documentation on the invasiveness of common tansy.

Biological Control for Industrial Sites In Saskatchewan, industrial corridors are a source for the growth and spread of weeds that eventually invade agricultural land. In Saskatchewan, there are 115,000 miles of roads that are administered by rural municipalities and 16,200 mile of highways that are under the jurisdiction of Saskatchewan Highways and Transportation.

On September 9, 1999, a presentation on the biological control of leafy spurge was presented at the at the fall tour (Regina, SK) of the Industrial Vegetation Management Association for Manitoba and Saskatchewan. The presentation was made at an industrial land site. In the audience were representatives of the herbicide and herbicide application industries. The Contain and Control model for leafy spurge was explained in detail. At the site, beetles were released on several unknown dates during the 1990's and they had reduced the population of leafy spurge. Part of the presentation was on how biological control fits into an integrated control plan for the weed. The issue is the degree of control that is obtained following the release of biological control agents. First, compared to herbicides, biological control agents slowly decrease the size of weed populations. Second, biological control agents suppress weeds. Therefore, seed could

always be present and potentially can move and establish the weed in a new site. Generally, herbicides should be used to contain large infestations of weeds like leafy spurge and biological control agents should be released within the containment area.

In Saskatchewan, the herbicides that are registered for weed control on industrial land are not well known (Table 5). At many presentations, information was given on the names and use of industrial herbicide products. Owners and occupiers of road right-of-ways were encouraged to use the appropriate registered herbicide for the control of scentless chamomile and leafy spurge.

Table 5. Herbicides registered for the control of scentless chamomile and leafy spurge on road right-of-ways land.

Herbicide Use Classification		Registered Use for Industrial Herbicides	
Industrial	Agricultural Equivalent	Scentless Chamomile	Leafy Spurge
2, 4-D LV ester	2, 4-D LV ester		Yes
Amitrol 240			Yes
DyCleer	Banvel II	Yes	Yes
Escort	Ally	Yes	
Tordon 101	Grazon		
Tordon 22K		Yes	Yes
Transline	Lontrel	Yes	

Project Activity 4. Develop a schedule of biological control sites for leafy spurge and other weeds for inspections and monitor.

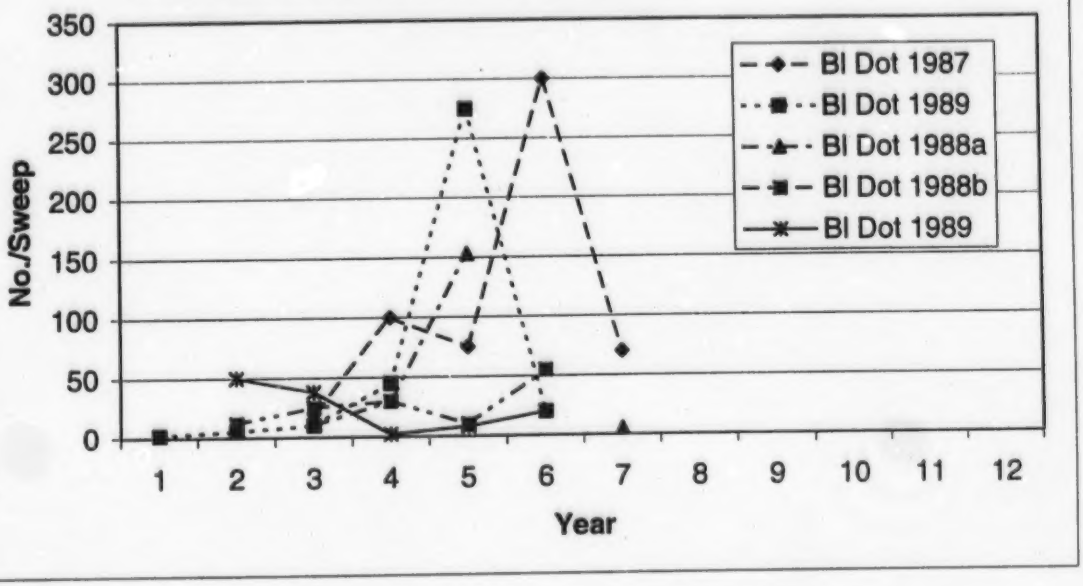
Achievements

Leafy Spurge Site Monitoring Between 1988 - 1995 there were yearly projects for the collection and redistribution of leafy spurge beetles throughout the province. Beetle establishment was measured by recording the number of adult beetles per sweep in a sweep net. The information was tabulated and lost when a computer hard drive failed. A version of the table used in the 1996 monitoring project for leafy spurge was found on a diskette. The table with its format was used as the basic design for reporting beetle monitoring. The results from monitoring beetle release sites between 1999 and 2001 were added to the table. The original table listed 154 sites, which was reduced to 74 sites. Sites were removed from the list because the beetles did not establish, a site was destroyed or lost, or the designated contact person could not be located. The sites judged worthy of monitoring were listed in U-Pick Spurge Flea Beetle Information Guide for 1999. This information guide was updated for 2000, 2001 and 2002. The 2002 edition of the guide contained information for 184 release sites. The monitoring schedule for 2000, 2001 and 2002 was based on this document.

An indication of leafy spurge beetle increase after establishment was obtained from the five best sites from the 1988 - 1996 data (Figures 5 - 7). Beetle number per sweep was the criterion used to select the five best sites. The trend with the black dot beetles was a rapid population increase followed by a rapid population decrease on the best sites (Figure 5). This suggests that black dot beetles should be monitored yearly and collected during the year when their population is high. High population numbers were not recorded for the brown dot beetles (Figure 6). In the United States, Mundal, et al. 2000, reported low population numbers following establishment. Beetle

numbers for the black beetle (*A. lacertosa*) increased during the three years that the species was monitored (Figure 7). In the United States, the order of *Aphthona* spp. flea beetles productivity in controlling leafy spurge according to Mundal (2000) is *A. lacertosa* (black)/*A. czwalinae* (black) followed by *A. nigriscutis* (black dot), *A. flava* (copper), and *A. cyparissiae* (brown dot).

Figure 5. The 5 best sites for the establishment of black dot spurge flea beetle (*Aphthona nigriscutis*)



In the field, species of leafy spurge beetles are difficult to identify. Positive identification is based on the genitalia (Harris 2000a-d).

The brown dot beetle (*A. cyparissiae*) is 3 - 4 mm long, with a brown to dark brown scutellum (the gap at the top of the wing covers) (Harris 2000a). This description is clear but there is evidence of interbreeding. According to Harris (2000a): "The female genetalia suggests that *A. cyparissiae* may be interbreeding with its sibling species *A. nigriscutis* in Canada". In Saskatchewan, there was a tendency to release brown dot beetles near sites where black dot beetles had been previously released. This gives the two species the opportunity to interbreed.

The black dot beetle (*A. nigriscutis*) is 3 - 4 mm long, with a black scutellum (gap at the top of the wing covers) (Harris 2000d). There are two black beetles (*A. lacertosa* and *A. czwalinae*) established on spurge in Canada (Harris 2000b). According to Harris (2000b), *A. czwalinae* is more tapered at the front than the rear, whereas *A. lacertosa* is equally tapered. Also, the rear upper hind leg of *A. czwalinae* is black, but in stock obtained from the United States, it is brown and hence similar to *A. lacertosa*.

Figure 6. The 5 best sites for the establishment of brown dot spurge flea beetle (*Aphthona cyparissiae*)

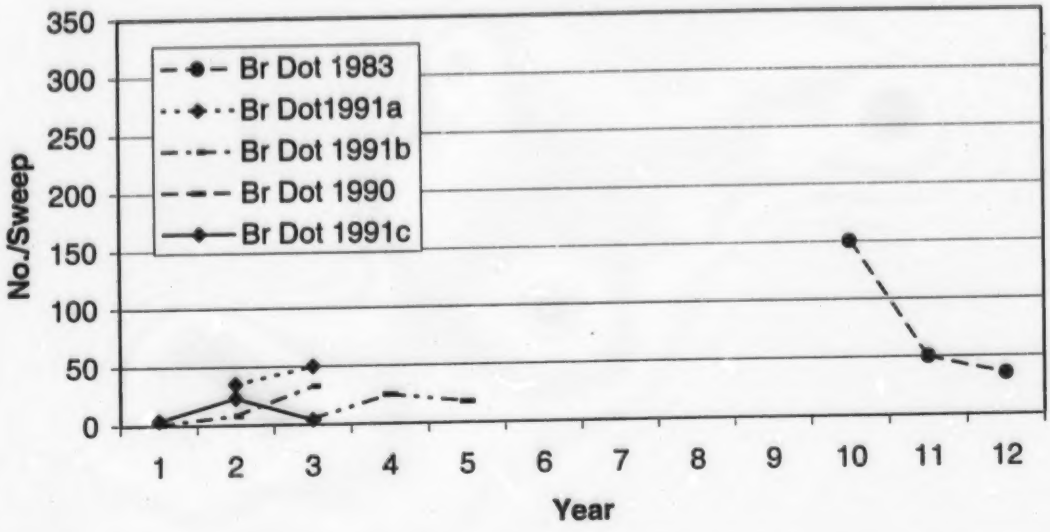
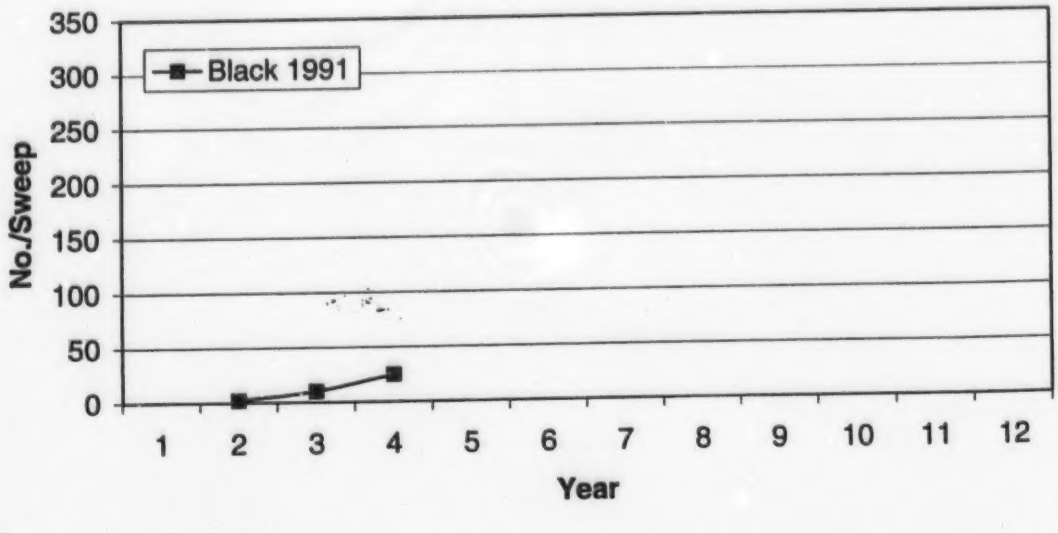


Figure 7. The 5 best sites for the establishment of black spurge flea beetle (*Aphthona lacertosa*)



Since 1996, black beetles have been imported from the United States. Most of the beetles are black but a percentage, which varies from sample to sample, are a brown colour. These are most likely black dot since most releases is the United States are a mixture of *A. lacertosa, A. czwalinae* and *A. nigriscutis*. Therefore, at a release site in the province, a collector is most likely to have more than one species in a sweep net.

Sites with a history of successful leafy spurge beetle establishment were given a higher priority for monitoring. The establishment of the black leafy spurge flea beetle in Saskatchewan was good in 2000 and when established, the beetle controlled leafy spurge in a 'halo' around the release point.

Leafy Spurge Beetle Collection and Release During 2000, black beetles were collected on industrial land east of the Joanne Goulet Golf Course in Regina, and released near Silton, Indian Head and Saskatoon (Meewasin). A second collection of black beetles was made from the site for re-release in provincial pastures. In the same year, 2000 - 2500 black beetles were collected and released in Corman Park #344.

Monitoring during 1999 - 2001 found that brown dot beetles had established at many locations in the province. At some sites, the reduction in the populations of leafy spurge did not meet the client expectation for satisfactory weed control. In these situations, clients were urged to be patient.

Scentless Chamomile Site Monitoring A table, similar to the table for leafy spurge, was designed for reporting on the establishment of biological control agents that control scentless chamomile. The table for scentless chamomile contained information that was derived from release forms and monitoring data. The table of information was included in an electronic report titled: Scentless Chamomile Biocontrol Agent Information Guide for 1999. This report was updated for 2000, 2001 and 2002. The monitoring schedule for 2000, 2001 and 2002 was based on this document. The number of sites monitored is presented in Table 6.

Table 6. Number of release sites monitored.

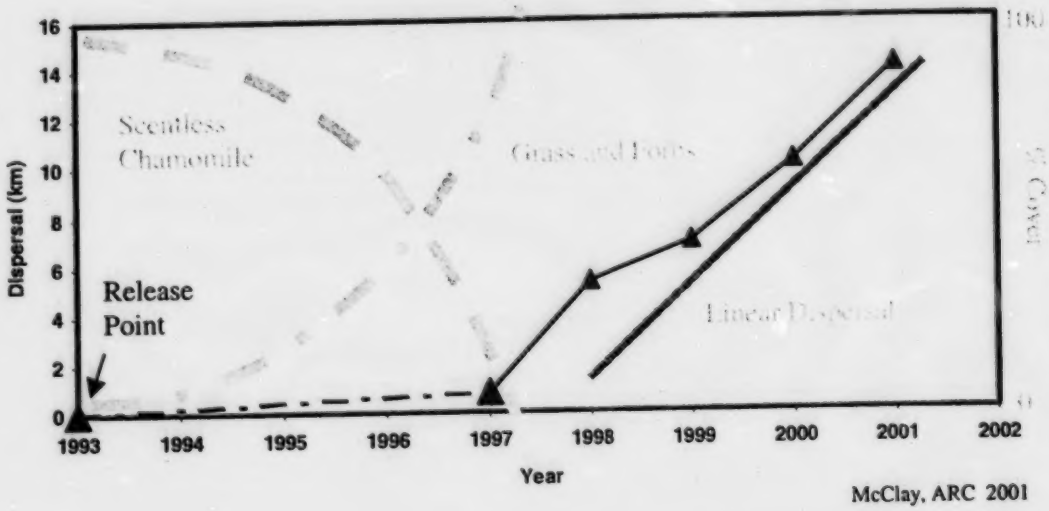
	Year Site Monitored			
	1999	2000	2001	Total
Scentless Chamomile				
Seed Weevil	44	15		59
Stem Weevil		2	4	6
Gall Midge		9	12	21
Leafy Spurge				
Flea Beetles	19	36	40	95

The best time to find a scentless chamomile seed weevil is 3 to 4 years after a release. During the first four years after release, seed weevils travel a few hundred metres from a release point (McClay 2001c, Figure 8). From the fourth to the eighth year after release, agent dispersal was linear.

In Saskatchewan, seed weevils are often released in disturbed sites with scentless chamomile

(Bowes, personal observation). When grasses and forbs invade, the weed becomes a minor to rare species (Figure 8). The best opportunity to find seed weevils is after their population increases for 3 years and before the weed becomes a rare plant in the vegetation.

Figure 8. The dispersal of scentless chamomile seed weevils from a release point.



Value of marking release sites with a Global Positioning System Global Positioning System (GPS) readings were recorded for all of the release sites that were monitored between 1999 and 2001. These readings are included in the information guides for scentless chamomile and leafy spurge. Site with a known GPS reading are easy to locate for monitoring and agent collection. A GPS reading is recommended for all new leafy spurge and scentless chamomile release sites. On January 2000, the United States reduced their security on output data from satellites. The accuracy when using a GPS reading to relocate a release site is 2 - 3 metres. This is more than adequate to find released biological control agents. The accuracy for GPS readings that were recorded in 1999 was 15 m. It is recommended that new GPS reading be obtained for sites that were monitored before 1999 and for all new release sites.

Herbicides and Leafy Spurge Beetles It is hypothesised that the collapse of leafy spurge on a parcel of industrial land in Regina during 2000 occurred because of black and brown dot leafy spurge beetle pressure, with or without the assistance of herbicides. Information on the application of herbicides is not available. This site is east of the Joanne Goulet Golf Course and south of Wascana Creek. In 2001, leafy spurge was not found on the site. Multiple releases, starting in the early 1990's, were made on this site. The majority of the beetles on the site were

black beetles. In 1999 and 2000, this area was an excellent site for beetle collection. In 2001, leafy spurge had disappeared and the beetle numbers were very low.

Black Beetle Establishment The black beetle are established on at least 33 release sites in Saskatchewan. Not all of the release sites were monitored during the same year. During 2000, the range of beetles per sweep was 4 - 8 on the five best release sites in the province (Table 7). During 2001, there were 5 - 15 beetles per sweep on the five best sites. This indicates that the black leafy spurge beetles are increasing in the province. In the 2002 U-Pick Leafy Spurge Flea Beetle Information Guide, there are 88 release sites with mostly black beetles. Most of the black beetles have been released since 1996.

Table 7. Establishment of leafy spurge black beetles in the five best sites in the province.

Year 2000			Year 2001		
Rural Municipality	Year of Release	Number of Beetles/Sweep	Rural Municipality	Year of Release	Number of Beetles/Sweep
Estevan #5	1998	8	Preeceville #344	1998	15
Mankota #45	1998	7	White Valley #49	1998	12
McKillop #220	1988	7	Sherwood #159		12
Lunsden #189		6	Huron #223	1998	5
Edenwold #158	1996	4	Huron #223	1998	5

Brown Dot Beetle Establishment The brown dot beetle are established on at least 27 release sites in Saskatchewan. Not all of the release sites were monitored. During 2000, the brown dot beetles ranged from 7 - 10 on the five best sites (Table 8). In 2001, the range was 4 - 5 beetles on the five best sites. Based on the five best sites, there were fewer brown dot beetles in 2001 than in 2000. In the 2002 U-Pick Leafy Spurge Flea Beetle Information Guide, there are 59 release sites with mostly brown dot beetles. Most of the brown dot beetles were released in the early 1990's.

Table 8. Establishment of leafy spurge brown dot beetles in the five best sites in the province.

Year 2000			Year 2001		
Rural Municipality	Year of Release	Number of Beetles/Sweep	Rural Municipality	Year of Release	Number of Beetles/Sweep
Longlaketon #219	1989	10	Laurier #38	1983	5
Lunsden #189	1992	8	White Valley #49	1991	5
Enniskillen #2	1990	7	Carmichael #109		5
Estevan #5	1992	7	Preeceville #334	1991	5
White Valley #49	1991	7	Caron #162	1990	4

Black Dot Beetle Establishment Mostly black dot beetles were found on 11 release sites in the province. During 2000, black dot beetles were found on three of the five sites monitored (Table 9). On these sites, black dot beetles ranged from 2 - 6 beetles per sweep. In 2001, the range of mostly black dot beetles was 1 to 4 beetles per sweep. Based on the best sites, there were fewer black dot beetles in 2001 than in 2000. In the 2002 U-Pick Leafy Spurge Flea Beetle Information Guide, there are 36 release sites with mostly black dot beetles. Most of the black

dot beetles were released in the late 1980's and early 1990's.

Table 9. Establishment of leafy spurge black dot beetles in the five best sites in the province.						
Year 2000				Year 2001		
Rural Municipality	Year of Release	Number of Beetles/Sweep		Rural Municipality	Year of Release	Number of Beetles/Sweep
Perdue #345	1991	6		Carmichael #109	1988	4
Mankota #45	1980s	2		Carmichael #190	1989	2
Longlaketon #219	1990	2		Huron #223	1989	2
				Battle River #438	1988	2
				Huron #223	1988	1

When is it worthwhile to collect? In the United States, the recommendation is to collect when a sweep of a sweep net yields 1 - 2 beetles or 500 beetles can be collected in five minutes (Merritt 2000). Sweep the area with a sweep net, leave the site undisturbed for 5 - 15 minutes before sweeping again. In Saskatchewan, there are sites, which are suitable for collection (Table 7 - 9). For information on release sites in the province, consult the 2002 U-Pick Leafy Spurge Flea Beetle Information Guide, which is available in e-mail format from Extension Agrologists. Because the number of beetles per sweep varies from year to year, a potential collection site should be sampled before making a large scale collection for re-release.

Leafy Spurge Beetle Performance On many sites, the density of leafy spurge has been reduced but seed is continually being produced on some plants. Leafy spurge has invaded most of this pasture and has greatly reduced the forage that is available for grazing (Figure 9).

Figure 9. Reduction in the density of leafy spurge after the beetles were released near the post.

Leafy spurge beetles (*Aphthona* spp.) were released in this pasture during the late 1980's and 1990's (Figure 9). The beetles have established but they have not thinned out leafy spurge sufficiently for adequate cattle grazing. It is not known if and when there will be adequate leafy spurge reduction for cattle grazing.

Some of these sites with leafy spurge can be used for cattle grazing (Figure 10). In this location, the leafy spurge beetles (*Aphthona* spp.) have established and have sufficiently thinned out leafy spurge for cattle grazing. The pictures in Figures 9 and 10 were photographed in the same pasture.

Figure 10. Reduction in the density of leafy spurge from leafy spurge beetles.

Leafy spurge beetles were found on all of the sites sampled in the Forsythe Grazing Co-operative pasture near Tugaske, SK (Figures 9 and 10). Over the last 10 years, many releases of black dot, brown dot and recently black beetles were made. When the pasture was monitored, low numbers (3, n=8) of beetles where found at all of the monitored sites. The two photographed sites in Figures 9 and 10 show how well the beetles are controlling leafy spurge. Continuous feeding by the larvae of the beetles on the roots of leafy spurge has decreased the density of the weed. Generally, producers are disappointed when leafy spurge is present on sites, which have beetles. In the pasture, the producers are not pleased with the performance of the leafy spurge beetles because the rate of recovery of the grazing land from biological control is exceeded by the spread of leafy spurge onto grasslands. Contain and Control is not an option for these producers because leafy spurge is spread over the entire pasture.

Scentless Chamomile

Project Activity 5. Contact all stakeholders involved with the release of scentless chamomile biological control agents to collect general information on the weed and develop an updated inventory of sites.

Achievements

Inventory of Release Sites An inventory of the sites where the biological control agents established on scentless chamomile was completed in 1999 and update during 2000, 2001 and 2002 (Bowes 2002a). The text for the 1999 inventory was an update of the information in the Integrated Biocontrol Strategies for Noxious Weeds, Field Reference Manual (Thompson 1997). Added to the original text was the most recent information for the three biological control agents that attack scentless chamomile (McClay 1999abc). These agents are the scentless chamomile seed weevil (*Omphalapion hookeri*), stem weevil (*Microplontus edentulus*) and gall midge (*Rhopalomyia tripleurospermi*). The inventory is a tabular list of release sites for the three agents. The format used for the release sites is similar to the format that was used for the leafy spurge biological control agents. The new report was titled: 1999 Scentless Chamomile Biocontrol Agent Information Guide. The guide was e-mailed to all Extension Agrologists in Saskatchewan during June 1999, May 2000, April 2001 and May 2002. Added to a new guide was the monitoring information from the previous year.

An example of an inventory entry for a biological control agent is presented in Table 10. Information for a site was obtained from a release form, which is completed after a biological control agent is released. Each release was assigned a unique number. No all of the release forms with a unique number were found in the inventory files, which were stored in Regina. Dr. DeClerck-Floate and Darlene Fisk (ADD #5) copied and forwarded their information on the scentless chamomile biological control sites. The copied information was used to complete the inventory on past release sites. Site location is documented by a legal description and a GPS reading. For monitoring, GPS readings are needed to find the release sites. GPS readings were found to be accurate within 2 - 3 m. It is recommended that a GPS reading be recorded for all new release sites.

Table 10. Inventory data collected for the scentless chamomile seed weevil during scentless chamomile site monitoring.

RM 98 ED 7	Release Date	Release No.	Flowering Stems #/m^2	Follow-up Year	Adult # Found	% Heads Infested
NE 24-11-17 W2	7-Jun-00	60	>35	2000	0	
SK-00-153						
Contact Person:	E. Moats		Phone #: 848-2384 GPS: N 49 55.831' W 104 11.910'			
Comments: Release between road, road right-of-way and abandoned dugout.						

Monitoring Method: Scentless Chamomile Seed Weevil The measurement for establishment is the number of adult seed weevils that an observer finds on scentless chamomile flowers during a 30 minute search in June. It is important to look for immature flowers that have white petals 1 to 5 mm emerged. Do not be alarmed if an adult cannot be found. Only 60 adults are released at a site. It is recommended that the first time to monitor should be three years after release. If no adults are found, then the site should be visited at least once more during a different year. The success rate for weevil establishment is 75% so the problem with monitoring is fining a few adult weevils among many scentless chamomile flowers (McClay and De Clerck-Floate 1999).

Project Activity 6. Contact Alberta Research Council (ARC) to updated general information and future plans for biological control of scentless chamomile.

Achievements

Research Information The scientist responsible for biological control of scentless chamomile at the Alberta Research Council is Dr. Alec McClay. After a telephone call in 1999 for up-to-date information, Dr. McClay prepared three information leaflets, which contained the latest research findings on the scentless chamomile biological control agents. During 2000, Dr. McClay supplied technical information on how to set up mass rearing of the seed weevil. Plans for the mass rear the gall midge were discussed but never implemented for two reasons. A suitable place for mass rearing using fine-screen cages and daily plant care could not be found. A native parasite was found attacking the gall midge and it is important to research the significance of the attack before implementing a mass-rearing program.

In the spring of 2001, a native parasite was found attacking gall midges in the greenhouse at Vegreville. The gall midge population that was maintained over winter for infecting scentless chamomile plants the following spring contained a parasite. Because of the rearing problem, gall midges were not released in the spring of 2001. During the summer, Dr. McClay was able to rear parasite-free gall midges on scentless chamomile plants. In August, Saskatchewan received sufficient releases for 20 new gall midge sites.

Generally, parasites are known to attack gall midges. In the research facilities at Vegreville, parasites were known to attack gall midges in the galls of scentless chamomile. In the field, the parasite attack on the gall midge was too late in the life cycle of the gall midge to cause a high mortality rate. Dr. McClay is continually monitoring the timing of the parasite attack.

Seed Weevil Mass Rearing The technique for mass rearing the seed weevil involves fall weevil collection, over wintering and spring release. During August 2000, scentless chamomile seed heads were collected at the Canwood site in Saskatchewan and from plants kept in screened cages at Vegreville, AB. Insects were separated from the seed heads. Adult seed weevils were kept in feeding pails for 17 days and then were counted into 50 weevil lots. Over the 2000 - 2001 winter season, 2100 weevils were stored in an incubator at the Crop Protection Laboratory in Regina. Eight hundred survived. The mortality rate over the winter of 2000 - 2001 was 62%. This was higher than the 50% rate experienced by the Alberta Research Council. In the spring, the insects are counted into 60 weevil lots and distributed through out Saskatchewan. A detailed documentation for the procedure for over wintering seed weevils is available at the Crop

Protection Laboratory in Regina and in Appendix L3.

Scentless chamomile seed weevils (550) were mass reared over the 2001 - 2002 winter season at the Crop Protection Laboratory in Regina. Adult seed weevils were collected at Vegreville, fed cut scentless chamomile plants for 14 days at Saskatoon and transported to the Crop Protection Laboratory at Regina. The survival rate was 10% because of either poor feed quality, a parasitic wasp or unknown factors. The wasp that was found on the scentless chamomile cuttings was identified and found not to be a parasite of the seed weevil. The most plausible reason is the scentless chamomile food source. During 2001, precipitation that was received at Saskatoon during the growing season was the lowest ever recorded. The cut scentless chamomile plants were very dry and may not have been a suitable food source for the seed weevil.

Gall Midge Mass Rearing The technique for mass rearing the gall midge involves growing scentless chamomile plants from spring to fall in fine-mesh screen cages. Starting in the spring and continuing throughout the summer, scentless chamomile rosettes are dug up from a field, transplanted into four-inch pots, which are placed into 6 x 6 x 12 foot fine-mesh screen cages with 10% of the plants infested with gall midges. After 30 to 40 days, when a new gall a ppears on a plant, it can be transplanted into a field that is infested with scentless chamomile. Nine plants are required for a release. If this procedure is used in Saskatchewan, the harmfulness of the parasite that attacks the gall midge in the field needs to be known. The over winter population of gall midges could be obtained through a contract agreement with Dr. McClay or maintained at the Crop Protection Laboratory in Regina. At present, the quickest, most economical and safest method to mass rear the gall midge is to use the facilities at the Alberta Research Council in Vegreville, AB.

Book Review A book chapter for a new book on Biocontrol of Weeds in Canada, co-authored by Dr. McClay, was reviewed. Pertinent information from the book was added to the 2000 issue of the Scentless Chamomile Biocontrol Agent Information Guide, credited to Dr. McClay.

Biological Control Strategy In Saskatchewan, the biological control strategy for scentless chamomile is to develop super-sites by introducing the seed weevil, stem weevil and gall midge at the same site. This is the quickest way to discover the maximum suppression that the three biological control agents will have on scentless chamomile. In 2000, the seed weevil (*O. hookeri*), stem weevil (*M. edentulus*) and gall midge (*R. tripleurospermi*) were released at two sites, Coleville and Nipawin. At the Coleville site, all three species established. At Nipawin, the seed weevil and gall midge established but there was no evidence the stem weevil established. The stem weevils were released under screened cages. In the fall, the cages were removed. Stem weevils established on the Coleville site, which had a better quality screen cage to confine the adults during egg laying. In 2001, the stem weevil was re-released at Nipawin and released at Lang in good quality fine-mesh screen cages. Samples of scentless chamomile collected during 2001 from 2000 release locations contained no stem weevils. Scentless chamomile samples collected during 2001 from within fine-mesh screen cages contained stem weevils. Stem weevils are good fliers. Therefore, not being able to find a stem weevil may mean that the sampling procedure was not adequate to find a highly dispersed biological control agent. These sites should be re-sampled in 2002.

At three sites, Coleville, Nipawin and Lang, there have been releases of the three biological control insects in the same area. In 3 to 5 years, we should be able to start to monitor the combined impact of the three agents on scentless chamomile.

Stem Weevil Establishment Of the three biological control agents for scentless chamomile, the stem weevil is the most difficult to establish. To establish the stem weevil, fine-mesh screen cages are needed to keep the adults from dispersing from the release site. The adults are good fliers and they are thought to disperse rapidly from the release point. The cages are used for a few months. If weevil larvae are found in scentless chamomile stems next year, then the agent has established for one year. This establishment technique has been successful. The alternative is to use transplanted plants or distribute stems of scentless chamomile, containing the stem weevil during July. The insect has established successfully following the use of transplants with larvae in the stems of the weed. The technique of stem distribution is still under investigation.

Suitable technology is not available for the over-wintering of stem weevils in Saskatchewan.

Project Activity 7. Review, update and develop appropriate extension material for Saskatchewan.

Achievements

Extension Material Review Extension material for Saskatchewan was reviewed and need to be update because of new information that was supplied by researchers between 1999 and 2001. The seed weevil, stem weevil and gall midge were licensed for release in 1992, 1997 and 1999, respectively. The introduction of biological control agents in to Saskatchewan provided an opportunity for the use of integrated weed control techniques.

Twenty-one articles were written on various aspects of the integrated control of scentless chamomile. These articles appeared in The Rural Councillor, Crop Protection News, Regional Newsletters and The Saskatchewan Hay Report.

In 1999, a change in the information for scentless chamomile on the web site was recommended. Delete the information for scentless chamomile except the electronic article on identification from Weed Identification series and herbicide control by Len Juras (1997). The article by Dr. L. Juras was rewritten by Mr. C. Brenzil (2001) with the title, Scentless chamomile: Management with Herbicides. The ERDA information sheets should be added to the web site and hot linked to the article on control. Information from the ERDA information sheets was added by Mr. C. Brenzil in 2001 (Bowes and Brenzil 2000b, Douglas 1989, Kessler 1989a-d). These articles are still relevant. However, these articles lack a significant article published by Blackshaw and Harker (1997) on the flowering of winter and spring annual scentless chamomile plants.

Extension Material Development Information was developed on: how to stop the spread of scentless chamomile, weed awareness and on the biological control agents. To address these issues, a series of 'how to' articles were written and published in The Rural Councillor, which is the official publication of the Saskatchewan Association of Rural Municipalities. This is a quick effective way to distribute information to rural municipalities. All rural municipalities receive

copies of The Rural Councillor and are obligated to enforce The Noxious Weed Act through their employed Weed Inspectors.

The requirements for the scentless chamomile control program originated through two meetings that were called to plan a strategy to control the weed. These meetings were the forerunner of the Scentless Chamomile Working Group, which holds annual meetings to plan strategy for the control of scentless chamomile. The meeting are open to all private and public organizations that are interested in the control of scentless chamomile. The approach that was established at the first two meeting was awareness, education and research. These three guidelines were the bases for the extension program on scentless chamomile.

Integrated Weed Control The first article that was written and published in The Rural Councillor explained the benefits of integrated weed control for scentless chamomile (Bowes 1999a). Long-term management of scentless chamomile depends on an integrated approach, which includes management with biological organisms, herbicides, mechanical equipment such as mowing and hand picking. This approach was used throughout the project.

Plan for Control Plan for Scentless Chamomile Control was the third article published in The Rural Councillor (Bowes 1999c). In the article, it was suggested that every rural municipalities should have a special policy and plan on how to control scentless chamomile. The policy was easy: we are going to aggressively deal with the weed. A plan was more difficult, but rural municipalities may fit into one of the following three plans: (1) Scentless Chamomile Free, (2) Isolated Scentless Chamomile Sites or (3) Major Scentless Chamomile Sites. This article also discussed the monitory issue. Money was in short supply. Therefore, the least expensive approach was always presented. This included making a conscience effort to keep the weed from entering scentless chamomile free or nearly free areas. Early monitoring was encouraged. The importance of the pick-bag-burn control method was emphasised.

These articles on the integrated weed control and planning for control provided the organization for future articles on the day-to-day activities for effective control of scentless chamomile.

Roadside Weed Control There was an immediate need to stop the spread of scentless chamomile throughout Saskatchewan. This need was addressed by starting an aggressive integrative weed program to control scentless chamomile that grows along roadsides based on the model presented in Figure 4.

Generally, scentless chamomile is found in many areas throughout Saskatchewan but it has not spread to all of the agricultural areas in the province. Scentless chamomile spreads by moving along roadsides with maintenance equipment and as a contaminant in seed.

Three articles on how to control scentless chamomile along roadside right-of-ways were written and published in the November 1999, December 1999 and January 2000 issues of The Rural Councillor (Bowes 1999d, 1999e and 2000a). These articles explained how to map the distribution of weeds, select an appropriate industrial herbicide for roadside spraying and evaluate roadside sprayers.

Mapping includes scouting to find scentless chamomile and then marking the location on a map. Weedy sites are controlled. Control is followed up by monitoring which determines the effectiveness of the treatment.

The appropriate herbicide for roadside right-of-way spraying is a licensed industrial herbicide. The article in The Rural Councillor explains how to calculate cost. Some herbicide treatments will control weeds for more than one year but there will be a residue, which may or may not be tolerated. While the article deals with the control of scentless chamomile, rural municipalities may want to control other weeds on their road right-of-way. Both of the above situations should be considered when calculating the cost of using herbicides on road right-of-ways.

In the province, many rural municipalities have a weed control program but it is based on spot spraying. A truck equipped with a handgun herbicide sprayer works well for controlling weeds that grow in patches but this type of sprayer is not suitable for applying herbicides to road right-of-ways. These sprayers need to be upgraded. Rural municipalities must decide if they want to own a roadside sprayer or contract roadside spraying to an industrial applicator. When making a decision on roadside spraying, rural municipalities were encouraged to maintain their spot-spraying program.

Scentless Chamomile Contaminated Seed Purchasing scentless chamomile free seed was part of many presentations that were made throughout Saskatchewan. Scentless chamomile is spreading in the province as a contaminant in forage and annual crop seed. Owners and occupiers of agricultural and industrial land should purchase or use certified seed only after the Certificate of Purification has been examined. If scentless chamomile is listed as a weed in a seed lot, do not purchase the seed. Always buy seed that is scentless chamomile free.

Information Availability Many of the presentations in the province were at meetings, which were organized by Extension Agrologists. The integrated control program for scentless chamomile recognised the importance of Extension Agrologists for providing on-going information to Weed Inspectors. This led to the posting of three presentations on the Agriculture Presentations Archives web site of Saskatchewan Agriculture and Food. These presentations focused on roadside weed control and, the biological control of leafy spurge and scentless chamomile. In addition, information was sent to Extension Agrologists, upon request.

Between 1999 and 2001, six articles containing the most up-to-date information about scentless chamomile biological control agents was written and published in the CROP PROTECTION NEWS (Bowes 1999bfg, 2000a and 2001bc).

Articles on the distribution of scentless chamomile in northeast and northwest Saskatchewan were published in the northeast and northwest newsletters (Bowes 2000b and 2001a).

In the fall of 2000, an article on the weed called: Hitchhiking Weeds was published in The Saskatchewan Hay Report (Bowes 2000f).

A poster was prepared on the integrated control of scentless chamomile and presented during November 2000 at the yearly meeting of the Expect Committee on Weeds (Bowes and Brenzil

2000a). An electronic copy of the poster was prepared, burnt on a compact disc and mailed to Mr. Dan Cole, Alberta Agriculture, Dr. McClay, Alberta Research Council and Dr. DeClerck-Floate, Lethbridge Research Centre.

The information gained from the distribution of scentless chamomile along roadsides, railroads and waterways, and around grain elevators-terminals was combined and published in a provincial distribution map during (Anonymous 2002a). Mr. B. Champagne, Manager of the Statistics Branch for Saskatchewan Agriculture and Food, provided advice on a presentable format for the information. The map was used in presentations throughout the province and was sent to anyone who requested information on the distribution of the weed. This map increased the awareness of scentless chamomile in Saskatchewan.

Information booths on the integrated control of scentless chamomile were manned at SARM conventions on March 6 - 9, 2000 in Regina, March 12 - 15, 2001 in Saskatoon and March 4 - 7, 2002 in Regina. The booths were busy 90% of the time. Information was delivered on all of the methods and their appropriate use for the integrated control of scentless chamomile.

Mowing Scentless Chamomile An article on the use of mowers to control scentless chamomile was published in the June issue of The Rural Councillor (Bowes 2000h). Mowing to control scentless chamomile is very controversial. When roadsides are mowed once a year, in the fall, when there is heavy dew, mowers provide an excellent vehicle for scentless chamomile seed movement. Because some mature scentless chamomile seed does not shatter until the seed stock is struck with a sharp blow, wet rotary mowers are effective for transporting seed. If you want to use a rotary mower to prevent scentless chamomile from setting seed, then multiple mows, starting in June with the mower set as high as possible for the first mow, must be used. Lower the mower for each successive mow treatment when flowers appear.

Some rural municipalities in Saskatchewan want to ban mowing. This is not a Saskatchewan only issue. The Rural Municipality of Strathcona, around Edmonton, has discussed the issue of a ban on mowing. Mowing for scentless chamomile is and will be an on-going issue. The solution for this problem is to control scentless chamomile with herbicides in the spring and mow roadsides in the fall for reasons other than weed control.

Posted on the Web Site The 10 articles that were written and published in The Rural Councillor are posted on the web site of the Saskatchewan Association of Rural Municipalities after a minimum time delay of two months after an article appears in print (Bowes 1999ac-e, 2000hikl and 2001d).

The Awareness Issue For rural municipalities that are scentless chamomile free, to remain free of the weed, they must be aware of the weed and be able to identify it. In 1999, several rural municipalities experienced difficulty identifying scentless chamomile from the black and white photograph in the Identification leaflet (Kessler 1989b). These rural municipalities requested coloured photographs of scentless chamomile to help with identification. Upon request, colour photographs were e-mailed to rural municipalities. Two rural municipalities requested 20 and 25 print copies of a temporary coloured identification leaflet for meetings.

During the winter of 1999 - 2000, three one-page handouts were designed with coloured photographs to help with awareness and identification (Anonymous 2000b-d). A request for funds to print an update of the scentless chamomile identification leaflet and two new awareness posters was approved by The Agri-Food Innovation Fund Technology Transfer Program (project number 20000189). New coloured pictures, which were photographed by Mr. C. Brenzil, replaced the black and white photographs of scentless chamomile in the old identification leaflet. Two posters, Wanted Dead and Scentless Chamomile Free, were prepared for a proactive approach for the control of scentless chamomile. Mr. C. Massier, of the Communications Branch, Saskatchewan Agriculture and Food, helped to professionally design the identification leaflet and posters. The numbers of copies printed were: 10,000 of the Scentless Chamomile Identification Leaflet, 5,000 of the Wanted Dead poster and 3000 of Scentless Chamomile Free poster. All three handouts can be obtained from The Publication Distribution Centre, Saskatchewan Agriculture and Food. In January 2000, copies of the three new handouts were mailed to all rural municipalities. The Publication Distribution Centre sent copies of the three handouts to all Rural Service Centres. An e-mail, documenting the use of the publications was sent to all Extension Agrologists and Client Service Assistants. Following the distribution of these handouts, very few telephone calls requested information on: 'what does scentless chamomile look like?'. These publications improved scentless chamomile awareness throughout the province.

Biological Control An important part of an integrated control program is biological control. In Saskatchewan, biological control for scentless chamomile is new and not very well understood. The seed weevil, stem weevil and gall midge were released for the control of scentless chamomile during 1993, 1997 and 2000, respectively. Articles on the three biological control agents were published in the November 2000, December 2000 and February 2001 issues of The Rural Councillor (Bowes 2000kl and 2001d). These articles contained the most up-to-date information for the agents. The seed weevil and gall midge successfully established in Saskatchewan. Both species are increasing. There is evidence that the stem weevil is establishing. The impact that any of these agents will have on scentless chamomile will not be known until all of the insect populations increase to their maximum density and then fluctuate around an equilibrium with the weed. The lack of quick control disappoints the owners or occupants of land with scentless chamomile. Also, the owners or occupants of land are disappointed that the impact of the seed weevil is on seed and not on the vegetative part of the scentless chamomile plant. This suggests that scentless chamomile biological control agents should be released in areas where the weed is difficult to control and likely to quickly spread.

A comparison of *The Noxious Weed Act, 1984*, to other noxious weed acts was completed and a report was forwarded to the Crop Development Branch.

Project Activity 8. Develop a plan of action in consultation with partners, including public awareness and media campaigns.

Achievements

Consultation with Partners During January 1999, a meeting of representatives from organizations that own or occupy land, which is known to harbour scentless chamomile, was

held in Saskatoon. Also attending the meeting were research scientists and extension workers. At this meeting, the participants agreed that actions were required for three challenge areas: 1) Awareness, 2) Research and 3) Co-operation-Co-ordination. Weed awareness throughout Saskatchewan is extremely important to prevent the spread of scentless chamomile to new sites. Also, the members decided that it was desirable to hold future yearly meetings on scentless chamomile.

The next meeting was held on February 2, 2000. At that meeting, the participants agreed that the formation of the Scentless Chamomile Working Group (SCWG) was the first step in co-operation and the co-ordination of an integrated scentless chamomile control program. Participants indicated there are other organisations involved in the management of vegetation that should be made aware of how easy it is for humans to transport scentless chamomile. Membership in the Scentless Chamomile Working Group includes representation from grain elevator companies, herbicide applicator companies, railway companies, Saskatchewan Extension and, Saskatchewan Highways and Transportation. Other meetings were held on May 30, 2000 and October 3, 2001 to plan strategy for integrated weed control and to update the committee members on the latest information.

The plan of action was to deliver a program for the integrated control of scentless chamomile by using and supporting the agricultural information structure that has work well in Saskatchewan for many years. Information on scentless chamomile awareness included awareness, education and control was delivered at regular meeting that were organized by Extension Agrologists. Some Extension Agrologists organized special meetings that were designed to deliver a complete package of information on scentless chamomile. Rural municipalities were encouraged to have a weed management program for scentless chamomile and leafy spurge. Background information was supplied to Extension Agrologists and Weed Inspector were encourage to first contact their regional Extension Agrologists for information on the control of noxious weeds.

The general plan to control scentless chamomile, which is based on integrated weed control, is complete. Emphasis is on the delivery of information on how to use integrated weed control. The most important issue is to inform those who do not have scentless chamomile that they do not need to get the weed. The other main issue is detail. How is biological control working? Is pick-bag-burn a waste of time? What is the value of mowing? What herbicide should be used?

A pro-active plan for the integrated control of scentless chamomile was presented at regional meetings in the province and was presented at the 2000, 2001 and 2002 Weed Inspector Training Clinics. The plan stresses competition. Road rights-of-ways must be seeded to competitive grasses. Use herbicides to kill scentless chamomile but try to put the herbicide on the weed. Develop a four-step plan for using herbicides. The four steps are:

- Investigate the history of weed control in the problem area.
- Scout for scentless chamomile (weed survey).
- Control the weed with herbicides.
- Monitor treated areas for herbicide effectiveness.

Biological control agents should be released on scentless chamomile in areas where the agents will thrive and from which the weed is least likely to spread. Eventually, the agents will spread over the weed problem area and help to suppress weed populations.

Research activities were carried out by Agriculture and Agri-Food Canada, CAB International and The Alberta Research Council.

Co-operation-Co-ordination was with Extension Agrologists, CAB International, Rural Municipalities, SARM and Weed Inspectors. Extension Agrologists organized meetings for PowerPoint presentations with different sectors of the agricultural community (presentations on CD). Electronic photograph were documented and sent to CAB International to give Dr. H. Hinz a better understanding of the scentless chamomile problem in Canada (photo selected from 1999 - 2000 photographs on CD). Rural Municipalities were sent a plan, including cost estimates for controlling scentless chamomile on road right-of-ways with herbicides (Appendix H). Presentations were made at SARM's mid-term convention and an information booth was manned at the spring conventions. With Clark Brenzil, the latest information was presented yearly to Weed Inspectors at Weed Inspector Training Clinics.

Public Awareness Between April 1999 and March 2002, there were 64 presentations at meetings, 34 print articles and 6 interviews.

Mapping Scentless Chamomile Mapping scentless chamomile started in 1999 when rural municipalities were asked to mark the distribution of the weed growing on their roadsides (Appendix H). The purpose of mapping the distribution of scentless chamomile was to: find where the weed is growing, estimate the cost of control with herbicides and help rural municipalities decide if they should apply herbicides or hire a herbicide application company. Often when a rural municipality decided to apply herbicides, they needed to purchase or construct a roadside sprayer. Municipal maps and instructions were mailed to 297 rural municipalities. The presence of the weed was marked with a 'hi-lite' pen on provincial highways and rural municipal roads. By September 2001, 222 replies were received. A computer program was designed to estimate the cost of herbicides and their application to control scentless chamomile on a road right-of-ways. Integrated weed control, using biological control, the seeding of perennial forage species, pick-bag-burn or spot herbicide treatments, was suggested for the remainder of a right-of-way. Each rural municipality, which has scentless chamomile, received a cost estimate for roadside weed control. In the reply, the miles of municipal and highway roads with scentless chamomile were totalled and the costs for chemical control with or without a commercial application cost were estimated.

In 2000, rural municipalities were asked to mark the distribution of scentless chamomile along railway right-of-ways, around grain elevators-terminals and along waterways. In addition, in 2000, rural municipalities that did not respond to the 1999 distribution survey were given the opportunity to respond. A cost estimate was sent to all rural municipalities that returned a new or updated scentless chamomile distribution map (Appendix H). In 2001, a third information package, containing distribution maps, was prepared for rural municipalities that did not respond to the 1999 and 2000 scentless chamomile distribution surveys. These information packages were delivered to the rural municipalities at the June 2001 SARM Division meetings.

After all of the information was obtained from the survey data, information was not available for 75 rural municipalities. Extension Agrologists and rural municipalities were e-mailed and

telephoned, respectively, to complete the needed information for the 75 rural municipalities. Extension Agrologists were asked if scentless chamomile was presence or absence in a rural municipality in their district. When the Extension Agrologists were not sure, the rural municipality was telephoned and asked the same question. When scentless chamomile was not present, the rural municipality was categorized as: No Scentless Chamomile. When the weed was present, the rural municipality was included in the category: Scentless Chamomile Presence Known - specific sites undocumented.

Two distribution maps were developed and presented at the 2002 Spring SARM convention. The distribution of scentless chamomile along provincial highways and grid roads was presented on one map. The other map showed the presence - absence of scentless chamomile in rural municipalities. Added to this map was occurrence of the weed growing around grain terminals, and along railways and by water bodies.

In Saskatchewan, scentless chamomile was found growing on the right-of-ways of 3,681 miles of provincial highways and municipal roads. In the province, 867 miles of provincial highways and 2,814 miles of municipal roads harbour the weed. Because not all of the rural municipalities returned a response to the survey, the miles of road right-of-ways with scentless chamomile are underestimated. In Saskatchewan, there are 16,200 miles of provincial highways and 115,000 miles of municipal roads. At present, only a small percentage of roads in Saskatchewan have scentless chamomile growing on their rights-of-ways.

Scentless chamomile is present in 199 of the 297 rural municipalities in Saskatchewan. In 13 rural municipalities, scentless chamomile was not found growing on road rights-of-ways but was found growing in farmyards (4), fields (4) and urban centres (3), along railways (1) and grain elevators (2). These sites are a source of first introduction for the weed into a rural municipality when the weed was not found growing along road rights-of-ways. It is speculated that human activities could be involved with the appearance of the weed in farmyards, fields and urban centres. The weed can hitchhike a ride with human activities.

For those rural municipalities that mapped scentless chamomile growing along provincial highway and grid road rights-of-ways, the weed was also found growing along railways (36), around grain elevators (27) and along water bodies (78). Moving water is an excellent vehicle for transporting scentless chamomile. The general pattern appears to be the introduction of scentless chamomile into areas of high human activity. Then the weed finds its way from sites of first introduction, via road rights-of-way, to water bodies. Once in water, the weed moves quickly.

Brad Champagne, Manager of the Statistics Branch for Saskatchewan Agriculture and Food, providing advice on a presentable format for the map and printed the map.

The mapping survey indicated that 199 rural municipalities have the weed and 98 are scentless chamomile free.

Saskatchewan Highways and Transportation The distribution of scentless chamomile was mapped for three highway districts in the province (Bowes 2000c-e). Because some rural

municipalities did not respond to the survey, the highway district maps were not complete.

Provincial Scentless Chamomile Map Information received from the surveys was used to develop a final scentless chamomile distribution map for the province.

Scentless Chamomile Maps on CD Municipal maps showing the distribution of scentless chamomile along railroads, roads and waterways and around grain elevators-terminals were prepared and burnt on to compact disks. The 256 distribution maps on the compact disk were prepared from the scentless chamomile weed surveys that were conducted from 1999 to 2001. Also included on the compact disks was a manual (22 pp) to explain the use of the maps and how integrated weed control will help to prevent the spread of scentless chamomile. Seven one-page notes contained hyperlinks to allow users to jump to maps. On May 18, 2001, compact disks were mailed to 29 members of the Scentless Chamomile Working Group, which included extension workers, grain companies, railways companies, research scientists and Saskatchewan Highways and Transportation.

Scentless Chamomile Working Group The progress of this project was presented at the regular meetings of the Scentless Chamomile Working Group on May 30, 2000, October 3, 2001 and April 19, 2001. Minutes of the three meetings were mailed to members of the Working Group. At the May 30, 2000 meeting, the membership suggested four activities. 1) E-mail articles published in The Rural Councillor to all Extension Agrologists. Instead, Extension Agrologists were notified that the articles are posted on SARM's web site. 2) Write an article on the distribution of scentless chamomile in Saskatchewan. This article appeared in the July issue of The Rural Councillor. 3) Write an article in The Rural Councillor on who should be contacted for the control of weeds on industrial land. This issue was re-visited during a subsequent meeting, which was held on October 3, 2001. The membership decided that a list of contacts should be tabulated and sent to all municipalities within the province. Surprisingly, appropriate contacts were difficult to locate and a list was not sent to rural municipalities. 4) Start the mass rearing of biological control agents for scentless chamomile. Mass rearing of the seed weevil was started over the 2000 - 2001 and 2001 - 2002 winter seasons.

SARM Conventions A meeting was held with Mr. D. Tumback, SARM, to plan on how to deliver information at the SARM Conventions. An information booth was set up in a prominent location at the 2000, 2001and 2002 Spring Conventions and presentations were made at the 2000 and 2001 Fall Mid-Term Conventions. The booths were busy 90% of the time. Information was delivered on biological control and how the agents fit into integrated control for scentless chamomile. This was an excellent way to deliver information to rural municipalities and respond to concerns about how to enforce The Noxious Weed Act.

Information to Media Through Interviews Information on awareness of biological control agents for scentless chamomile and leafy spurge was delivered to the media following interviews with Ms. M. Hryniuk. Four articles were published in the Farm & Food Report (Hryniuk 1999, 2000, 2001a, 2001b). Three articles increased the public's knowledge of biological control agents. The fourth article focused on the first time that scentless chamomile seed weevils were successfully over-wintered at the Crop Protection Laboratory in Regina. One of articles on scentless chamomile and one on leafy spurge generated two interviews by Mr. D. Simms, CKBI

radio.

During September 2000, information on how the biological control agents for scentless chamomile attacked the weed was delivered to the media in an Agri-Food Innovation Fund newsletter following an interview with Mr. A. Rosseker. The title of the article was: Bugs Used to Attack Scentless Chamomile.

Following interviews at Mr. R. Sexsmith's farm on November 2000, Ed White of the Western Producer wrote a feature article (1 newspaper page) on scentless chamomile. Also, interviewed were Mr. B. Swanson, Extension Agrologist and Mr. R. Sexsmith, Farmer. The article was excellent for increasing noxious weed awareness to the owners or occupants of agricultural and industrial land. The views of a Farmer, Extension Agrologist and the Noxious Weed Coordinator were expressed in the news article.

Advisory Meeting Verbal Up-Dates Five-minute verbal up-dates on this project were presented at the Saskatchewan Weed Advisory Meetings, which were held on April 19, 2000, April 18, 2001 and April 10, 2002.

Seed Weevil Releases Near Wetlands From 1999 to 2000, the scentless chamomile seed weevil successfully survived on scentless chamomile growing next to cattails at two sites and on the weed growing along and in a stream (Figure 11 an 12). This suggests that the seed weevil can be

Figure 11. Seed weevils can habitat scentless chamomile when the weed grows in the wettest part of its environmental range next to cattails.

used to reduce seed production on scentless chamomile that is growing along waterways. The reason why fall releases that were made near sloughs during 1995 and 1996 failed to establish is unknown. It is speculated that wetter than normal years, during the first year after release, may be devastating because the seed weevils have not dispersed very far from their release point. Perhaps the weevils should be released on scentless chamomile plants that are growing at or just above the high water level.

Figure 12. Seed weevils survived on scentless chamomile that grows on disturbed sites in an intermittent stream. Scentless chamomile sites with seed weevils are marked with circles.

Project Activity 9. Develop a schedule of workshops, farmer meetings and field days for presentation and information distribution.

Achievements

A formal schedule was not developed. Presentations were made in cooperation with other organizations, according to their schedules (ADD Boards, Crop Production Meetings, Extension Agrologists meetings, Midland Vegetation, SARM, Saskatchewan Highways and Transportation, Parks Canada and Weed Districts). This was effective, because presentations on awareness, education and control were made to many people who work in different areas of agriculture and Saskatchewan industries. This approach was most effective for attendees who did not have

scentless chamomile growing on their agricultural or industrial land because it made them aware of the weed.

Project Activity 10. Inform media of field day presentation opportunities.

Achievements

Presentation Advertisement Most presentations were delivered at regional and special meetings, which were organized by Saskatchewan Agriculture and Food. The media received notification of the events, including the presentations on scentless chamomile and/or leafy spurge. Handouts, which include reprints of articles published in The Rural Councillor, were made available at all presentations.

Project Activity 11. Conduct site inspections and hold field days as required for redistribution of established biological control agents.

Achievements

Release Site Inspection From 1999 to 2001, 86 scentless chamomile biological control release sites where monitored (Table 6). During this time, some release sites were visited more than once. Biological control agent populations never increased to sufficient numbers for collection on most Saskatchewan sites. For the seed weevil and gall midge, Dr. McClay believes that over wintering the insects in incubators and, growth rooms or green houses is better than outdoor collecting and release. These recommendations were followed. During 2000 - 2001 and 2001 - 2002, scentless chamomile seed weevils were over-wintered and released the following spring.

During summer of 1999, 44 release sites for the scentless chamomile seed weevil were monitored (Table 6). The presence and number of weevils usually exceeds expectations. There was a general point of view held by producers that seed weevils will control scentless chamomile plants rather than suppress the output of seed. When land users found out that the seed weevil eats seed and has no impact on suppressing the scentless chamomile plant, their interest in biological control diminished.

From 1999 to 2001, plant succession was occurring at the release sites and scentless chamomile was becoming a minor species in a grassland vegetation. These sites had small patches of scentless chamomile, which will support only one or two collections of the weevil. The Canwood site was the only site suitable for collection in Saskatchewan. In 2000, weevils were collected at Canwood and at Vegreville, AB for over wintering and mass release in the spring of 2001. During the fall of 2000, the owner of the land at the Canwood site mowed the area. Therefore, the weevils had to be collected at the Vegreville, AB site during 2001.

Two field days were held to promote awareness and control of the weed.

Seed weevil populations increased from 1999 to 2000 and then decreased (Figure 1 and 2, and Project Activity 2).

Gall midge establishment was excellent and the first sighting of a scentless chamomile plant with visible galls and lost vigour is impressive.

Project Activity 12. Establish mother colonies of new biological control agents as required.

Achievements

New Release Sites During 1999, 2000 and 2001, biological control agents were obtained from Dr. McClay. The numbers of biological control agents that Saskatchewan received from Dr. McClay and that were over wintered in the province are presented in Table 11. Each year, Extension Agrologists, individuals and rural municipalities requested biological control agents for scentless chamomile. A list of those requesting biological control agents was maintained each year. The agents are shipped to Extension Agrologists. Extension Agrologists distribute these biological control agents, in their district. An Extension Agrologist or Weed Inspector completes and returns the release forms. Each year, new releases were added to the sites, which are listed in the e-mail publication: the Scentless Chamomile Biological Control Agent Information Guide.

Table 11. Number of biological control agents released for the control of scentless chamomile.

Year and Over winter agency	Biological Control Agent		
	Seed weevil *Omphalapion hookeri*	Stem weevil *Microplontus edentulus*	Gall midge *Rhopalomyia tripleurospermi*
1999 Alberta Research Council	19		5
2000 Alberta Research Council	10	2	8
2001 Alberta Research Council	11	2	20
2001 Crop Protection Lab.	13		

Seed Weevil Health Extension Agrologists were very concerned that the 1999 shipment of scentless chamomile seed weevils contained a high percentage of dead adults. Seed weevils like to play dead so it was difficult to judge the health of a weevil when released. The general opinion was that mortality was high. During 2000 and 2001, the populations of seed weevils that were shipped from Vegreville, AB to Saskatchewan, appear to be vigorous and healthy.

Stem Weevil Mortality Over the winter of 1998 - 1999 there was a high mortality of stem weevils in the storage facilities at Vegreville. This unfortunate event prevented any new releases in 1999. During 2000, the stem weevils were released in screened cages.

Seed Weevil Capture Collecting scentless chamomile biological control agents from established sites and moving them to new areas that do not have the agents accelerates the spread of biological control throughout the province. Because seed weevils feed on the foliage of scentless chamomile in the spring before flowering and in the fall before over wintering, there are theoretically two times when seed weevils can be collected and redistributed. During the summer of 2000, several techniques were tested to determine the best method for the capture and re-release of the scentless chamomile seed weevil.

In late May, a few seed weevils were feeding on scentless chamomile plants and they were collected with a BugBuster (a modified small vacuum sold as Dust Buster®). The number collected by the BugBuster was too small for early insect collection. BugBusters are commonly used to capture various types of biological control agents (De Clerck-Floate personal communication). However, when seed weevils are laying eggs or feeding in July, the suction from the vacuum was not sufficient for weevil capture. The weevils tend to feed deep in new plant growth at the apex of the plant, hide from view and are difficult to vacuum out.

An insect sweep net is another common method that is used to capture insects. Weevil collection was poor with a sweep net. When a scentless chamomile plant receives a quick movement, the weevils play dead and drop from the plant. Therefore, most seed weevils fall from the plant before a sweep net passes through a plant. A stick was used to move plants slowly to a sweep net, as the net passes through a scentless chamomile plant. The stick-sweep method improves collection efficiency on isolated plants. In a scentless chamomile dominated stands, it is difficult to move the stick slowly and the sweep net quickly to capture seed weevils. There does not appear to be a good way to collect large numbers of weevils quickly before the female lays eggs in the spring.

The best way to collect seed weevils for mass re-distribution is to capture the insects in the fall and over winter them for a spring release. Pick the seed heads in the late summer - early fall when seeds in the seed heads start to mature. Crush the seed heads with a single head seed thrasher to encourage the seed weevils to leave the seed heads. The hand pick-crush method appears to be the best method to capture seed weevils. When a hedge trimmer mechanically cuts seed heads, a long stiff peduncle remains attached to each seed head. This makes hand thrashing difficult to nearly impossible. Hand thrashing by placing seed heads in a cotton bag and rubbing the bag between two hands is inefficient.

When using the pick-crush method to capture seed weevils, the weevils must be separated from the crushed seed head residue. Dr. Alec McClay is researching several different types of simple collectors. Crushed seed head residue is placed in a container, weevils climb up the walls and they are captured at the top of the devise. Seed weevils like to climb. In 2000, scentless chamomile sprigs were placed on crushed seed heads to attract feeding insects and then the sprigs plus the weevils were moved to feeding trays. Also, individual seed weevils were picked from the crushed residue.

After capture, the weevils must be fed scentless chamomile for at least 14 days. In Saskatchewan, in 2000, large numbers of weevils were placed in 20-litre pails with cut vegetative shoots of scentless chamomile. Four to five cut shoots were added daily for 17 days. Other feeding methods tried were less successful. When a large number of weevils are captured, feeding them on sprigs of scentless chamomile in water picks is too time consuming. When potted scentless chamomile plants are used, many weevils tend to hide in the soil and many large plants are needed to avoid a heavy load of weevils. To prevent weevil escape, potted plants must be kept in screened cages. The weevil load number on scentless chamomile plants is unknown. In 2001, seed weevils that were fed a daily diet of cut vegetative shoots of scentless chamomile did not appear vigorous and by the 14th day, there was a high adult mortality. The reason for the feeding success during 2000 and failure during 2001 is unknown. However, 2001 was very dry

and it is speculated that the cut scentless chamomile plants may have lacked sufficient moisture to meet the requirements of the seed weevils. Appendix L3 contains the best known method for capture, over winter storage and release of seed weevils.

It is important to find a low-cost, quick method to introduce the gall midge into new sites in the province. Because gall midges over winter in galls, it may be possible to release the gall midge into new locations by collecting scentless chamomile plants, which have galls, in the spring, after the soil thaws but before general vegetation growth starts in the spring. On April 2, 2002, three gall midge release sites were visited in the Prince Albert-Canwood area. At this time of the year, scentless chamomile plants with galls were impossible to distinguish from plants without galls.

Results and Conclusions

1. Lists of the locations, where biological control agents for scentless chamomile and leafy spurge were released, are available at Rural Service Centres in e-mail format. In 1999, the contact person for each release site for leafy spurge beetles was telephoned and this person provided a verbal assessment of a release site. When the scentless chamomile and leafy spurge release sites were monitored, an estimate of the number of agents was added to the list. GPS readings were recorded for all of the sites monitored and were included in the e-mail reports. The reports were updated yearly and titled; 1) 1999, 2000, 2001 or 2002 Scentless Chamomile Biocontrol Agent Information Guide and 2) 1999, 2000, 2001 or 2002 U-Pick Leafy Spurge Flea Beetle Information Guide.

2. The Global Positioning System (GPS) provides sufficient position accuracy to locate sites where biological control agents were previously released. GPS greatly increases the number of sites that can be monitored in a day. The alternative is to phone the contact person, arrange a meeting to visit the site.

3. The 1999 monitoring of release sites indicated that the scentless chamomile seed weevil (*Omphalapion hookeri*) has successfully established in Saskatchewan. The weevil is mobile and is therefore usually found in low numbers at sites. In the future, seed weevils should be released at as many new locations as possible.

4. In 1999, a model was designed to show how to use integrated weed control for scentless chamomile that grows along road right-of-ways. The model was well received. Herbicides are recommended for a road shoulder and any combination of biological control, grass competition, pick-bag-burn and spot herbicide treatments are recommended for the remainder of the right-of-way. The most controversial part of the model is the width of the shoulder that should be treated. Each mile of road right-of-way needs to be assessed and the roadside width that is treated should be minimal. The model was delivered as a one-page handout and included in PowerPoint presentations.

5. By the winter of 1999 - 2000, a sufficient number of rural municipalities had returned their distribution map for scentless chamomile to a start a large-scale plan to control the spread. Scentless chamomile control was based on the integrated weed control model.

By the fall of 2001, 222 rural municipalities had returned their scentless chamomile distribution maps. Because of the interest from such a large number of rural municipalities, presentations concentrated on a proactive plan to control the weed throughout the province. Because many of the areas where scentless chamomile grows in the province were documented, the information was burnt onto a compact disk and sent to the owner and occupiers of land that is used for industrial purposes (grain elevators-terminals, railroads, roads and water bodies). Owners and occupiers were encouraged to plan for the control of scentless chamomile before spring growth.

6. During the winter of 1999 - 2000, a computer program was developed, which estimated herbicide product and application cost, to help rural municipalities budget for scentless chamomile control. The cost estimate helped rural municipalities decide if they should apply herbicides or use the services of a commercial applicator. The distribution maps showed where the weed is located. Articles in The Rural Councillor explained how to control scentless chamomile that grows on a roadside right-of-ways.

7. The best way to increase the spread of the scentless chamomile seed weevil throughout the province is to continue to make introductions to new weedy areas. The percentage of seed heads with a scentless chamomile seed weevil and the average number of larva per seed head increased from 1999 to 2000 but decreased from 2000 to 2001.

8. Audiences attending the regional presentations during 1999 and early 2000 were very interested in scentless chamomile. Awareness and control of scentless chamomile were the two important issues. Many land users (agriculture and industrial) were not aware of the weed because they could not identify it. Second, many people were not aware of the potential losses from the weed. These concerns motivated the design of posters to help with public awareness. The use of the scentless chamomile identification leaflet and the two new posters, Wanted Dead and Scentless Chamomile Free, greatly helped to promote weed awareness.

9. Gall midge (*Rhopalomyia tripleurospermi*) establishment on scentless chamomile in Saskatchewan was excellent one year after their release. The first sighting of a scentless chamomile plant with visible galls and lost vigour is impressive. The gall midge appears to be the best of the three released biological control agents for scentless chamomile.

10. During 2000, all three biological control insects for scentless chamomile were released in the same area near Lang, Coleville and Nipawin. In 3 to 5 years, the combined impact of the three agents on scentless chamomile should be monitored. This is important because for some weeds multiple agents are required for effective weed control. The released agents are the scentless chamomile seed weevil (*Omphalapion hookeri*), stem weevil (*Microplontus edentulus*) and gall midge (*Rhopalomyia tripleurospermi*).

11. Monitoring the combined impact of the three agents on scentless chamomile will provide the maximum effect that biological control will have on suppressing the weed. The three release sites were selected for specific reasons. At Coleville, scentless chamomile is confined to a small isolated area. The agents may increase more rapidly at Coleville than

at sites with many large populations of scentless chamomile. This site could provide the first estimate of the maximum effect that the three agents will have on the weed. The Nipawin site will provide information on how well the agents perform at a northern location. The agent's performance at Lang will provide information on the effectiveness of the three agents on scentless chamomile growing in a large annual crop area.

12. Sufficient information was available by the fall of 2000 to start the mass rearing of the scentless chamomile seed weevils and gall midges in Saskatchewan. Scentless chamomile seed heads containing adult weevils were collected and thrashed. Adult weevils were collected, fall-fed and over wintered at the Crop Protection Laboratory in Regina. In the spring, 13 released were made from the over wintered weevils in Saskatchewan. Initially the over wintering of gall midges appeared easy. Equipment (large screened cages) could have been loaned from Dr. McClay. The need for daily monitoring and pot watering for 1 hr per day, every day and a suitable location for large screened cages could not be met. While these issues were being addressed, Dr. McClay noticed that parasites were attaching gall midge larvae. Saskatchewan should not attempt to mass-produce gall midges until Dr. McClay's research on the impact of the parasite is completed.

13. Monitoring previous releases during the summer indicated that the black leafy spurge flea beetle (*Aphthona lascertosa*) is establishing and increasing in Saskatchewan. The beetles are starting to control leafy spurge. The black dot and brown dot flea beetle (*A. nigriscutis* and *A. cyparissiae*) have established at many locations in the province, but at some sites, they are not reducing the population of leafy spurge to a satisfactory level. The black leafy spurge flea beetle appears to be the better biological control agent.

14. Proactive information for weed awareness across the province was increased when the updated Scentless Chamomile Identification leaflet and the two new posters, Wanted Dead and Scentless Chamomile Free, were sent to all Rural Service Centres and Rural Municipalities in the province. This information was sent during January 2001.

15. By the fall of 2000, it became apparent that late fall was the best time for field days to show how galls reduce the vigour of scentless chamomile plants. The visibility of an agent's activity is important for client acceptance of biological control. Galls on scentless chamomile plants, containing the gall midge are remarkably visible in the late fall. Because winter annual scentless chamomile plants are frost tolerant, galls are easily spotted on green plants after the first killing frost in the fall.

16. During the summer of 2000, a parcel of industrial land located in northwest Regina was an excellent site for the collection of black and brown dot leafy spurge beetle for release throughout the province. In 2001, the leafy spurge population collapsed because of black and brown dot leafy spurge beetle pressure. Between 1999 and 2001, unknown herbicides were applied at unknown times on the industrial land. The importance of the herbicide treatments for controlling leafy spurge is unknown. The majority of the beetles on the site were black beetles. This site exemplifies the success that can be achieved by the use of biological control agents to control leafy spurge.

Indications for Further Development

1. An integrated weed management program, which uses herbicides to contain leafy spurge and control outliers, and beetles, sheep and/or goats to control the weed within a herbicide treated containment area, has sparked interest. Because biological control suppresses the weed populations, it is important to use herbicides to control the spread of the weed. When only biological control is used, the weed will continue to spread.

2. Methods, which increase the populations of the seed weevil (*Omphalapion hookeri*), stem weevil (*Microplontus edentulus*) and gall midge (*Rhopalomyia tripleurospermi*), are beneficial for the biological control of scentless chamomile. Mass rearing and release of biological control agents throughout Saskatchewan will increase the spread of the insects to all of the areas with scentless chamomile.

3. Any project that demonstrates how to stop the spread of scentless chamomile along road right-of-ways and from other industrial land will be helpful.

4. On sites were the beetles have established on leafy spurge but have not reduced the weed population to a sufficient level, there is a need to explain why this is happening. Some of these sites are not grazed and have a dense litter layer on the soil surface. Perhaps, the litter is adversely affecting the performance of the beetle by sufficiently cooling the soil in the spring and/or inhibiting the movement of larvae to leafy spurge roots.

Information on Communication and Information Sharing

1. The ten articles published in The Rural Councillor have greatly increased the awareness of scentless chamomile. Generally, the articles provide information on 'how to' for the various components that are needed for a successful integrated weed control program. The articles have helped rural municipalities plan for roadside weed control. Cost estimates help rural municipalities with budgets. The project to map the distribution of scentless chamomile has greatly increased the awareness of scentless chamomile throughout the province. The article on mowing to control scentless chamomile explained the difficulties of repeated mowing to control the weed. The articles on biological control agents for scentless chamomile explained how the agents help to suppress seed production and plant vigour.

2. The on-going practice of designing presentations for audiences in different sectors in Saskatchewan has greatly increased awareness of scentless chamomile.

3. Articles published in The Rural Councillor are easy to access because they are posted on Saskatchewan Association of Rural Municipalities web site.

4. The proactive plan to control the spread of scentless chamomile by mapping the general

areas of weed distribution within the province will help owners and occupiers of industrial land to develop an early spring control plan.

5. Two radio interviews on the usefulness of biological control agents for scentless chamomile and leafy spurge resulted from interviews of article written by Ms. M. Hryniuk.

Information on Outputs and Measures as outlined in Project Evaluation Summary

1. Improved Knowledge Base: Development and delivery of a provincial scentless chamomile awareness and control program

   One new biological control agent gall midge (*Rhopalomyia tripleurospermi*) was released for the suppression of scentless chamomile.

   One hundred and eighty one existing release colonies were monitored.

   Four new mother colonies were established.

   Two plans of action, control of scentless chamomile on road rights-of-way and Contain and Control leafy spurge, were based on integrated weed control and delivered.

2. Increased Understanding: Increase knowledge and awareness of producers regarding controlling of persistent weeds (leafy spurge, toadflax, nodding thistle, scentless chamomile) by using biological control agents.

   Forty-seven winter meetings were organized by SAFRR.

   Ten news articles were written.

   Six interviews were granted.

   Ten to thirty attended field days and winter meetings.

   Demand and circulation of extension bulletins is presented in Table 12.

Table 12. Demand and circulation of extension bulletins.

Bulletins	Printed	In stock
Scentless Chamomile Identification, 0006	10,000	4,341
Scentless Chamomile Wanted Dead, 0007	5,000	1,480
Scentless Chamomile Free, 0008	3,000	921

Two surveys documented the distribution of scentless chamomile.

Seven workshops delivered awareness and control of noxious weeds.

Media campaigns were completed by SAFRR staff for each meeting and workshop delivered.

Increased Market Share/Sales/Production/Profits/Exports – Not applicable.

Increased Membership/Employment/Patents – Not applicable.

Identification and Dissemination of New Technological Opportunities

1. Mass rearing of seed-eating weevils (*Omphalapion hookeri*) appears to be the best way to increase the weevil's population on scentless chamomile.

2. Marketing of spray equipment for applying herbicides to small areas such as slough boarders and field edges, for the control of scentless chamomile, is needed. Also, needed is the marketing of industrial sprayers for road right-of-ways. Also, a technical evaluation service, for assessing older spray equipment for potential upgrade, is not generally available within the province. Modern boomless spray nozzles are popular with industrial spray contractors but there are not generally known by rural municipalities. Sprayers using this technology, which is suitable for scentless chamomile control, are not shelf items. Modern technology is available as modular units and is assembled, upon request, as new equipment by TrueNorth Specialty Products of Calgary.

Increased Knowledge of the Human Resource Base

1. Delivered integrated weed management programs for the control of scentless chamomile on road right-of-ways and leafy spurge that grows on road right-of-ways and pastures.

Diversification and Impact on Production/Producers/Marketplace

1. The integrated weed control plans within this project are not advanced sufficiently to have an overall impact. For example, leafy spurge beetles have been released after a Tordon 22K application in Mankota #45 but their impact is unknown. Similarly, black leafy spurge beetles have been released in the Corman Park #344 in the same areas as the brown dot beetles were released in the 1990s. In 2001, the areas with beetles were grazed with sheep. It is too early to assess the overall impact of integrated weed control.

2. The use of integrated weed control methods to control and suppress scentless chamomile is starting to have an impact. More municipalities are controlling the weed, which prevents spread. It is very cost effective to control scentless chamomile on industrial

land before the weed spreads to agricultural land.

3. Interest in biological control is increasing. Because of the project, Mr. Clark Brenzil, Provincial Weed Specialist, has received telephone calls from herbicide application companies about the collection, distribution and re-establishment of biological control agents.

(c) Personnel - Garry Bowes. Time on the project = 100%.

(d) Equipment - nil.

(e) Project Photos - Photographs (1999 photos, 2000 photos and 2001 photos) are on the compact disk.

(f) Innovation Fund Acknowledgment -

The following or equivalent is added to extension material; The Noxious Weed Management Program is funded by: Canada-Saskatchewan Agri-Food Innovation Fund through Saskatchewan Association of Rural Municipalities and Saskatchewan Agriculture and Food.

(g) Project Public Information Materials

Copies of the leaflet and posters are available in Appendix K.

1. Anonymous. 2000. Scentless Chamomile: Identification. 2pp.
2. Anonymous. 2000. Scentless Chamomile: Wanted Dead. 1p.
3. Anonymous. 2000. Scentless Chamomile Free. 1p.

Literature

1. Anonymous. 2002a. Distribution of Scentless Chamomile in Saskatchewan. Map, 1p.

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20. Bowes, G. 2000h. Mowing to Control Scentless Chamomile. The Rural Councillor. June Vol. 35 (5).

21. Bowes, G. 2000i. Scentless Chamomile Control on Roadsides, Do You Need to Upgrade Your Sprayer? The Rural Councillor. February Vol. 35 (1).

22. Bowes, G, 2000j. Special Reports for Rural Municipalities. 117 reports on the cost of controlling scentless chamomile along roadsides.

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24. Bowes, G. 2000l. The Scentless Chamomile Seed Weevil. The Rural Councillor. December Vol. 35 (10).

25. Bowes, G. 2001a. Control of Scentless Chamomile in Northwest Saskatchewan. Northwest Newsletter. 1p.

26. Bowes, G. 2001b. Parasitoids Delay Distribution of the Scentless Chamomile Gall Midge. CROP PROTECTION NEWS. Vol. 23 (4).

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